Low Level Alcohol and its Residual Effect on a Pilot's Threshold for Detecting Angular Motion

Regina G. Bolinger

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LOW LEVEL ALCOHOL AND ITS RESIDUAL EFFECT ON A PILOT’S THRESHOLD FOR DETECTING ANGULAR MOTION

by

Regina G. Bolinger

A Thesis Submitted to the
Graduate Studies Office
in Partial Fulfillment of the Requirements for the Degree of
Master of Aeronautical Science

Embry-Riddle Aeronautical University
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THRESHOLD FOR DETECTING ANGULAR MOTION

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This thesis was prepared under the direction of the candidate's thesis committee
chairman, Dr. John A. Wise, Center for Aviation/Aerospace Research and Department of
Aeronautical Science, and has been approved by the members of the thesis committee. It
was submitted to the Office of Graduate Programs and was accepted in partial fulfillment
of the requirements for the degree of Master of Aeronautical Science.

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ABSTRACT

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Title: Low Level Alcohol and its Residual Effect on a Pilot's Threshold for Detecting Angular Motion
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The purpose of this study was to examine a pilot's sensitivity to a change in angular motion after alcohol ingestion and determine the duration of effect after the time the blood alcohol content (BAC) reached zero. An earlier study determined that a pilot's threshold for detecting angular motion was affected by 30% with low doses of alcohol ingestion. An important question remaining is whether the pilot's sensitivity to angular motion will continue to be significantly affected after the time BAC reaches zero. Twelve instrument-rated pilots flew a partial panel rotating simulator under an in-flight scenario, and thresholds were measured before and after alcohol administration. As expected the pilot's sensitivity to angular motion (at BAC < 0.04%) registered a higher (> 30%) threshold and remained elevated when BAC returned to zero. However, within one hour after BAC reached zero, the mean thresholds had returned to their initial prealcohol level.
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Chapter One

INTRODUCTION

Spatial disorientation has been attributed to many fatal aviation accidents, especially with the absence of visual cues and lack of adequate attention to primary instruments, thus causing a pilot to depart from a normal flight attitude. The implication that alcohol and its residual effect impairs the sensitivity to perceive a change in angular motion may contribute to a pilot’s disoriented state. While pilots are generally taught to rely on their instruments, their overall situational awareness often includes a reliance on some proprioceptive and vestibular cues (see Glossary). An elevated threshold (see Glossary) for detecting angular motion could, therefore, have important implications in some flight situations. For example, if the pilot were not attending to the flight instruments when the aircraft began a descending turn due to autopilot malfunction, asymmetric fuel feeding, or other cause, an unsafe situation could quickly develop. Failure to identify such a departure from straight and level flight can be especially dangerous in high performance aircraft since airspeed can increase rapidly to levels such that there is a real possibility of exceeding the structural limits of the aircraft. As the thresholds for detecting motion around the yaw axis are generally less than that for detecting pitch motion (Clark & Stewart, 1968a), less sensitivity to angular motion would delay detection of such flight path deviations. Thus if the elevated threshold effect continues significantly after the time blood alcohol content (BAC) reaches zero, it could have deleterious effects after the time interval between drinking and flying that is generally considered safe, as has been suggested with respect to lingering positional alcohol nystagmus (PAN) and other nystagmic alcohol effects (Gibbons, 1988; Oosterveld, 1970a).

A recent study by Ross and Mughni (in press) demonstrates the possible effects of low alcohol level on the pilot’s sensitivity to detect changes in angular motion, showing that thresholds for the detection of angular motion increase for pilots who had been given
alcohol (at a level less than 0.04%). The pilots who were given alcohol showed an elevated threshold even when their blood alcohol content (BAC) reached zero, indicating lasting effects of alcohol on vestibular functioning.

There is evidence that the vestibular system remains affected by alcohol many hours after the BAC drops to zero. The duration of PAN and associated phenomena such as Coriolis stimulation has been shown to impair performance in visual tracking tasks and reaction times related to vestibular functioning (Schroeder, 1971c). If alcohol does affect vestibular functioning and the pilot’s sensitivity to detect angular motion, then an important question remaining is whether the pilot’s sensitivity to angular motion will continue to be significantly affected after the time the BAC level returns to zero. If the pilot’s sensitivity to angular motion remains affected after the 0.00% BAC level, the adequacy of the Federal Aviation Administration’s 0.04% BAC and eight-hour "bottle to throttle" rules becomes a concern.

**Statement of the Problem**

The purpose of this study was to examine the pilot’s sensitivity to angular motion (threshold) when blood alcohol content (BAC) was slightly below 0.04% to determine if a degradation existed in the angular motion thresholds (resulting in elevated perception thresholds). Also, the study considered the residual effect of alcohol on the thresholds for perceiving a change in angular motion by examining the decaying function of the elevated thresholds after the BAC levels reached zero to determine the duration of the alcohol effect on vestibular functioning that caused the thresholds to remain elevated. Threshold measurements were taken in the yaw plane before and after alcohol administration and in one-hour increments for three hours after the time the BAC returned to 0.00%.
Review of Related Literature

Interest in the effects of lower blood alcohol content (BAC) values on pilot performance has been heightened by the FAA's 1985 adoption of a rule that no person with a BAC of 0.04% or higher may act or attempt to act as a crew member of a civil aircraft. While past research has demonstrated that a high BAC results in large performance decrements in actual and simulated flight, the data available from experimental evidence with respect to the effects of low BAC on pilot performance are still somewhat limited and contradictory. The eight-hour "bottle to throttle" rule has governed behavior of the general aviation pilot with respect to alcohol consumption and flying. Generally, BACs in the 0.04% range and below appear to have statistically significant effects on pilot performance primarily when the flying tasks impose very high workloads or involve unexpected flight problems or procedures. Recent studies with such findings include those by Davenport and Harris (1992) and Ross, Yeazel, and Chau (1992). Other studies (Henry, Davis, Engelken, Triebwasser, & Lancaster, 1974; Taylor, Dellinger, Schilling, & Richardson, 1983) have failed to find significant flight performance decrements at low BAC levels. In 1985, Part 91 of the Federal Aviation Regulations (FARs) was modified to include a rule that no one could act or attempt to act as a crew member with a blood alcohol concentration of 0.04% or higher. A year later the regulation was modified to include an implied consent provision, under which the crew member is required to submit to an alcohol test when requested by a law enforcement official. One possible difficulty with this regulation is that it may imply to some crew members that it is safe to fly with a BAC that does not exceed 0.04%. Despite the existence of these regulations, according to Harris, Schroeder, and Collins (1995), a recent postmortem inquiry found 6% of general aviation fatal accidents during 1989 and 1990 involved pilots with a BAC of 0.04% or higher (Canfield, Kupiec, & Huffine, 1992). The National Transportation Safety Board, in its review of the accident statistics, believes that the presence of any alcohol in a pilot's blood jeopardizes safety. These
observations and conclusions raise a number of questions concerning the effects of low
doses of alcohol on performance (Ross, 1988).

The only study that examined alcohol effects on pilot performance in actual flight
was by Billings, Wick, Gerke, and Chase (1973) who determined the effects of alcohol on
pilot performance during actual flight in a Cessna 172. The researchers demonstrated that
when pilots flew under the influence of a BAC of 0.04%, a significant increase in major
procedural errors was found. Other aspects of pilot performance did not show any
significant performance decrements. Morrow, Leirer, and Yesavage (1990), in a
comprehensive study of alcohol’s effects on radio communications during simulator
flight, found no significant decrements due to a 0.04% BAC on course, radio, or severe
heading errors; but they did find impairment in severe altitude errors and summary
performance measures for older pilots (mean age 42 years), but not younger pilots (mean
age 25 years). Billings, Demosthenes, White, and O’Hara (1991) reported increased
errors by four pilots carrying out flights with a 0.025% BAC in a Boeing 727-232
simulator, but the results are difficult to interpret because the function relation
performance to BAC was variable with more total and serious errors made when the
pilots were tested with a 0.025% BAC than with a 0.05% BAC. Ross and Mundt (1986)
assessed the effects of alcohol (0.04% BAC) on the simulator performance of pilots and
non-pilots during straight and level flight and during an unusual attitude flight segment
where attention was diverted by other tasks. Alcohol significantly impaired performance
on some tasks and was most evident in recovery from unusual attitudes. In a recent study
using four air carrier crew members, Billings, Demosthenes, White, and O’Hara (1991)
found that their classification of serious errors, but not the overall number of errors,
increased significantly at a BAC of 0.025% when compared to baseline. However, at the
0.05% BAC level, both the serious errors and the overall number of errors were below
that noted for the 0.025% BAC level.
It has long been known that alcohol affects the functioning of the vestibular system (Aschan, Bergstedt, Goldberg, & Laurell, 1956). Impairment of vestibular function by ethanol in animals was first shown in 1842 when alcohol induced nystagmus (see Glossary) was demonstrated (Howard & Templeton, 1966). Barany and Rothfeld were the first to perform experimental studies in order to evaluate the effect of alcohol upon the vestibular system in rabbits (Howard & Templeton, 1966). Since that time this phenomenon has been reported repeatedly in humans and animals.

The human vestibular system comprises the nonacoustic portion of the inner ear and consists of three semicircular canals (see Glossary). These canals constitute angular accelerometers capable of sensing angular accelerations in any direction as the head is rotated (Falmagne, 1986). Angular accelerations of the head in the plane of a canal cause the endolymph (fluid contained in the semicircular canals) to flow in the canal due to its inertia which in turn deflects a cupula (see Glossary) that gives rise to a sense of turn. The semicircular canal/endolymph/cupula system acts as a heavily dampened angular accelerometer, responding to angular accelerations in its own plane and yielding sensations of angular rate. If, however, the acceleration is followed by rotation at a constant rate, the endolymph (see Glossary) catches up with the rotating canal, and the deflected cupula is restored to its rest position by virtue of its own elasticity (Gabriel, 1962). If audio and/or visual cues are not available, then a person erroneously thinks turning has stopped. This phenomenon has been used in the design of experiments for measurement of turning thresholds.

There are three manifestations of vestibular canal activity which have been used to determine threshold values (Falmagne, 1986). These are: (1) reports of feelings of rotation, (2) nystagmus (the pattern of alternate slow sweeps and fast return movements of the eye), and (3) oculogyral effect (the apparent movement of a point of light in the dark, see Glossary). While the effect of alcohol on nystagmus and oculogyral phenomena have received attention, the interaction of the sensations of rotation as affected by alcohol
has only very recently been studied (Ross & Mughni, in press). However, angular motion thresholds without the interaction of alcohol were tested by researchers as early as 1875 (Howard & Templeton, 1966). The recorded thresholds of perception of turn motion varied between angular acceleration values of 0.035 to 8.20 degrees per second\(^2\). Large variations between different determinations were attributed to the method employed and the apparatus used for threshold measurements. Later studies also revealed variations between different determinations. Howard and Templeton (1966) suggested that it is not easy to accelerate a human smoothly and avoid all extraneous sources of stimulation, and therefore experimenters have differed in their threshold determinations.

Duration of stimulus was also studied and it was determined that the product of acceleration and time remain constant (Falmagne, 1986). Thus for shorter times of application, greater accelerations are required to reach a given threshold. This product, known as Mudler’s constant, remains fairly constant for stimulus times of about 5 seconds or less. The observed values of Mudler’s constant range between 0.2 and 8.0 degrees per second\(^2\), depending on the participants and methods used (Gillingham & Wolfe, 1985). For further discussion see Mughni (1994).

Although the sensory systems (vestibular and visual) involved in spatial disorientation would appear to be affected by the ingestion of alcohol, the locus and nature of the effect are not established (Schroeder, 1971a). While some authors report that alcohol enhances vestibular responses, others indicate response suppression.

Although alcohol was known to affect the vestibular system through the development of a positional alcohol nystagmus (see Glossary), information concerning the effects of alcohol on nystagmic responses to angular accelerations was still contradictory. Barany (Howard & Templeton, 1966) reported no change in the duration of the nystagmic response following alcohol ingestion but noted that the subjective reactions were weakened. Manz (Schroeder, 1971c) found a prolonged duration of post-rotatory nystagmus, and later studies by Taschen, Schweitzer, Schulte, and Roth
in Schroeder, 1971b) all indicated that the nystagmic response was enhanced following alcohol ingestion.

In contrast, Forster and subsequent studies by Bochenek and Ormerdo, Ey, Di Guinta and Rosa, and others (Schroeder, 1971b) supported the view that alcohol exerts a suppressive effect on nystagmus. These differences in findings were attributed in part to the presence or absence of visual stimuli. Also, an additional factor concerns the effects of alertness on the nystagmic response. Studies by Collins (1968, 1980) showed that variations in alertness will alter the nystagmic responses to rotatory stimulation and that these variations may be manipulated by appropriate instructions. Schroeder (1971b) designed a study to investigate the influence of alcohol on the subjective and nystagmic responses to rotatory stimulation with and without visual fixation, and with the alertness of the participants controlled by instructions. Additional information was obtained concerning the effect of alcohol on a proposed relationship between the duration of the rotational turning experience and the duration of the spiral aftereffect (see Glossary).

Schroeder (1971a) has demonstrated that, in darkness, nystagmus depressed after alcohol consumption. He showed that ingestion of alcohol depresses both ocular nystagmus and vertigo sensations to rotatory or caloric vestibular stimulation when participants are in darkness, but in illumination, similarly provoked nystagmus is stronger than it is normally. This stronger nystagmus under illumination is not related to changes in vestibular sensitivity but to the depressive action of alcohol on the visual fixation mechanism. However, under these conditions where visual fixation is permitted during angular stimulation, nystagmus is increased due to the inhibiting effects of alcohol on the visual fixation mechanism. These studies demonstrated that the alcohol-lowered inhibition of nystagmus during angular acceleration results in significantly higher compensatory tracking errors than during static conditions. The method employed a rotational speed of 80 rpm and stimulus duration of 15 seconds. High rotational and
acceleration speeds may have contributed to this conclusion (Howard & Templeton, 1966).

Also, the adverse effect of alcohol on visual fixation during angular accelerations as well as the deterioration of tracking performance was investigated by Gilson, Schroeder, Collins, and Guedry (1972). They detected significant impairment at blood alcohol levels (BACs) of 0.027%. In the study, tracking performance was observed in the yaw as well as the pitch plane, and performance on a localizer/glide slope tracking task administered during angular motion resulted in a significant performance decrement under the lower of two levels of instrument illumination; the effect was not obtained when participants were stationary.

A second study by Collins, Schroeder, Gilson, and Guedry (1971) also found that, when stationary, the performance of the alcohol group was significantly poorer than that of the control group only during the testing session carried out one hour after completion of drinking. During angular acceleration the alcohol-control difference was significant for the 1-, 2-, and 4-hour test sessions when BACs were 0.074%, 0.073%, and 0.047%, respectively. No differences were found 8 and 10 hours post drinking (0.001% and 0.0% BACs). The effect was in part due to the improved performance of the control group across repeated test sessions, while the alcohol group still evidenced some performance impairment when compared to the predrink level. These findings suggest that, while an intoxicated person may perform some tasks adequately when stationary, performance can be impaired when motion is added.

A subsequent investigation by Gilson, Schroeder, Collins, and Guedry (1972) investigated the effects of display illumination and alcohol on tracking performance during static and angular acceleration conditions. Tracking performance under angular acceleration was significantly poorer one hour after drinking as compared to the control condition for both the low (0.027%) and moderate (0.077%) BAC, with the moderate alcohol group tested under low illumination conditions and showing continuing poorer
tracking performance two and four hours after drinking (0.076% and 0.041% BACs). Alcohol effects were not found when the subjects were stationary. The researchers reported that with alcohol, a dramatic impairment in tracking performance was observed only in the dynamic environment and not in the static environment. Thus, a pilot who drinks lightly may be convinced on the ground that the abilities are unimpaired and may feel safe to enter the cockpit. The study also suggests that while flying, particularly at night with dim display illumination, the pilot who encounters vestibular stimulation as a result of maneuvers, turbulence or some inner ear dysfunction may experience some blurring of vision. The visual control of the eye movements is reduced by the effect of alcohol, and vestibular control could then be predominant. While the effect of alcohol on the turning sensation was not studied, it is possible that the vestibular system of the pilot, and thereby the thresholds of turn perception could also be adversely affected.

An increase in nystagmus and decrease in tracking performance following alcohol ingestion was also found by Gilson, Schroeder, Guedry, and Collins (1972), both in the case of y (pitch) axis and z (yaw) axis oscillation. Alcohol effects were significant when tested one hour (0.081% BAC) and two hours (0.075% BAC), but not four hours (0.047% BAC) after drinking.

PAN can be exhibited long after blood alcohol reaches zero and can interfere with visual fixation so that nystagmus occurs and tracking is affected. There is still less information, and some contradictory data, concerning alcohol effects on subjective responses to angular acceleration (Ross & Mughni, in press).

Several studies have examined the effects of alcohol on vestibular functioning in terms of Coriolis and other subjective phenomena. First, the Coriolis effect, also called Coriolis illusion (see Glossary), is a false precept that can result from unusual stimulation of the vestibular duct system (Gillingham & Wolfe, 1985). The phenomenon occurs when the person has been rotating enough for the endolymph in the ducts to attain the same angular velocity as the head, and the sensation of rotation has ceased. If the
participant moves the head in a different plane from the plane of rotation, the other two sets of semicircular canals would be manifested. The speed of rotation and the rate and degree of head movement are responsible for the intensity of the Coriolis illusion. The effect of alcohol on Coriolis was studied by Ryback and Dowd (1970) and Hill, Schroeder, and Collins (1972). Ryback and Dowd (1970) measured subjective tumbling to plane tilts during rotation by having subjects move a handle bar to estimate the magnitude of perceived displacement. Subjective tumbling was significantly greater 8 to 15 hours post alcohol ingestion. While Ryback and Dowd (1970) indicated that their subjects reported increased sensation of tumbling after ingestion of alcohol, Hill, Schroeder, and Collins (1972) reported that no consistent alcohol effects were found on the intensity or duration of Coriolis sensations.

Alcohol’s effects on Coriolis responses were further investigated by Hill, Schroeder, and Collins (1972) in a study in which subjects made head tilts in darkness during constant rotation. Three groups (vodka, bourbon, and control) were tested 1, 2, 4, 8, 24, and 48 hours after drinking alcohol and orange juice, or only orange juice. No consistent alcohol effects were found on the intensity or duration of Coriolis sensations. The turning sensation due to angular acceleration showed a significant decrease in duration only when tested one hour after alcohol ingestion.

Schroeder, Gilson, Guedry, and Collins (1973) reported that alcohol significantly reduced the duration of subjects’ turning sensations following angular deceleration in darkness, but not when the turning sensations accompanied acceleration. The difference was attributed to the procedure employed that required subjects to judge their sensation of velocity during acceleration but not make such judgments during deceleration.

The possibility that alcohol effects may persist after blood alcohol levels reach zero has received only little attention. A study by Laurell and Tornros (1973) found significant decrements in the automobile driving performance of participants the morning after drinking when their BAC had reached zero. The poorer performance was unrelated
to subjective hangover symptoms. Yesavage and Leirer (1986) reported that Navy pilots flying an Orion simulator 14 hours after a peak BAC of at least 0.10% had poorer performance under hangover conditions for two of six variability measures and one of six performance measures. The differences in terms of actual flight deviation numbers were not large, however, and the situation was somewhat unusual (i.e., a takeoff involving the loss of two of four engines, both on same side, followed by an instrument approach and landing, still with the two-engine loss).

With respect to PAN duration, Ryback and Dowd (1970) found positional alcohol nystagmus (PAN) effects as well as increases in Coriolis induced nystagmus lasting up to 34 hours after ingesting alcohol. Oosterveld (1970b) reported that PAN could be observed as long as 44 to 48 hours post alcohol when the subjects were subjected to 2.5 G conditions. Goldberg (1966) had reported similar results lasting several hours. Hill, Schroeder, and Collins (1972), mentioned previously, also reported persisting effects of alcohol on PAN, in their case 24 to 32 hours after the ingestion of alcohol.

Despite the lack of strong evidence for hangover effects, Gibbons (1988) has made a convincing argument for a mechanism that could result in dangerous effects after blood alcohol levels reach zero. Alcohol diffuses into and out of the structures of the inner ear at a slow rate, upsetting the specific gravity relationships between endolymph and the structures of the inner ear that are necessary, together with visual input, for orientation and the prevention of vertigo and other disorientation phenomena. These vestibular effects can continue long after blood alcohol reaches zero. As mentioned previously, a manifestation of this process, positional alcohol nystagmus (PAN), has been shown to persist for as long as 48 hours after the intake of alcohol when the individual is subjected to increased G-forces. Gibbons (1988), a former regional flight surgeon for the FAA, suggests that a number of unexplained aircraft accidents involving reduced visual input could have been due to spatial disorientation occasioned by continuing alcohol effects in the vestibular system. In such cases there would be no indication during
autopsy of alcohol involvement in the accident. There is a need to determine if such
effects occur and the conditions under which they might affect flight safety.

A recent study by Ross and Mughni (in press) investigated the possible effects of
alcohol on the pilot’s sensitivity to changes in angular motion, showing that thresholds
for the detection of acceleration and deceleration of angular motion increased for pilots
who had been given alcohol (at a level less than 0.04%). The thresholds of alcohol
participants increased significantly after drinking and remained generally high after BAC
reached zero, while the placebo participants’ thresholds remained relatively constant.
Threshold measurements were made during three test sessions: 1) prior to receiving
alcohol drinks, 2) after receiving alcohol, and 3) after the subjects’ BAC had decreased to
zero. A placebo group was tested at the same times and with the same procedures except
that the only alcohol they received was 3 ml of alcohol floated on top of each drink to
provide the smell and initial taste of alcohol. The alcohol participants continued to show
an elevated threshold after their BACs reached zero, as might be expected because of the
known lasting effects of alcohol on vestibular functioning demonstrated by the
occurrence of PAN for as long as 48 hours after alcohol ingestion (Schroeder, 1971c). If
nystagmus could persist long after the detectable BAC returns to zero, then the threshold
of turn perception could also remain impaired for some length of time after BAC drops to
zero. A second study by Mughni (1994) failed to demonstrate that increased workload
further decreased the sensitivity to perceive angular motion, suggesting that the effect of
alcohol may alternatively be the result of the sensitivity of the inner ear to angular motion
(e.g., through changes in the specific gravity of the endolymph, rather than an attentive
phenomenon).
Statement of the Hypothesis

It is hypothesized that in the yaw plane a degradation exists in the pilot’s sensitivity to perceive angular motion (threshold) when blood alcohol level is slightly below 0.04% in comparison to a placebo group, and the threshold remains impaired after BAC returns to 0.00% for at least 3 hours (refer to Figure 1).

Figure 1. Hypothesis 1 states that in the yaw plane a degradation exists in a pilot’s threshold perception of angular motion when blood alcohol level is slightly below 0.04%. Hypothesis 2 asserts that the threshold will remain impaired for at least three hours after the point at which BAC returns to 0.00%.
Chapter 2

METHOD

Participants

The 12 participants for this study were derived from a student population of instrument rated pilots presently enrolled at Embry-Riddle Aeronautical University. Participants were assigned to equate groups with gender, flight hours, and drinking habits, with the restriction that each group contain the same number of males and females, have equal number of participants with current instruments ratings, have total flight time ranging from 100 to 1000 hours, and be similar in terms of their current drinking habits. Five males and one female were randomly assigned to each group. The average ages of the Alcohol and Placebo groups, respectively, were 22 and 23 years. Four of the six Alcohol group participants were current in terms of their instrument ratings, with an average of 261.83 hours of flight time (range of 210 to 320) and 32.33 hours of simulator time (range of 0 to 70). Five of the six Placebo participants were current in terms of their instrument ratings with an average of 346.17 hours of flight time (range of 207 to 700) and 32.67 hours of simulator time (range of 0 to 80).

The drinking habits were determined by using a Quantity-Frequency-Variability questionnaire (Cahalan, Cisin, & Crossley, 1969) which classifies a participant as a light, moderate, or heavy drinker (see Appendix A). Based on their responses on a modified version of the Quantity-Frequency-Variability (Q-F-V) approach, both the Alcohol and the Placebo groups included 1 light, 2 medium, and 3 heavy drinkers (see Table 1, Appendix B). No participant was accepted who was abstaining or attempting to abstain from alcohol, had any medical condition contraindicating alcohol consumption, or gave indications of a drinking problem.

Also, female participants were given an over-the-counter pregnancy test prior to the experiment to ensure no alcohol be given to a pregnant female. The participants signed a general consent form prior to the experiment (see Appendix C). The
experimental protocols used in this study were approved by the Institutional Human Subjects Committee and included the Michigan Alcohol Screening Test (refer to Appendix D), and a brief version of the Quantity-Frequency-Variability alcohol questionnaire combined with a questionnaire concerning the manner in which the participant thinks the alcohol might affect pilot performance (see Appendix A). The participants were paid for their participation.

**Apparatus/Instruments/Equipment**

The apparatus consisted of a modified ATC 610 procedures trainer simulator (ATC Flight Simulator Co., Los Angeles, CA) including an enclosed compartment with a chair (see Ross & Mughni, in press, for a more detailed description). The simulator was mounted on an electrically driven motor that could rotate the simulator at a determined rate. The simulator's motor gave more reliable rotation in a clockwise direction; acceleration was perceived as a right turn, and deceleration was perceived as a left turn. An adjustable potentiometer externally controlled the rate of rotation to determine angular velocity. The potentiometer was synchronized with a Matrix MR-500 quartz metronome for achieving a timed displacement, and a conversion chart gave the acceleration and deceleration value of the potentiometer scale with the metronome setting (see Mughni, 1994, p. 21). The potentiometer reading ranged between 0.066 degrees per second² and 2.54 degrees per second². An IBM computer stored simulator control inputs, instrument readings, and yoke button presses to be used for later analysis and was placed on the simulator behind the participant. Depressing the microphone button not only indicated input information to the computer but also illuminated a low wattage indicator light located on top of the enclosure to signal the experimenter when the participant felt a turning sensation. The computer also independently controlled the presentation of 1.4 cm by 0.7 cm numerals on an alphanumeric display unit located centrally on top of the simulator instrument panel 60 cm from the participant's eye. A blower provided fresh air to the enclosed chair. The enclosure was dimly illuminated by a light behind the
participant’s head. The participant’s head was placed in a headrest and secured with Velcro straps. The head position of the participant could be adjusted by the experimenter to place the head in a normal vertical posture (see Glossary). Thus, the participant retained the posture throughout the session. Deliberate head movement out of the adjusted headrest position was sensed by a capacitance system that illuminated a warning light displayed outside the simulator enclosure which was monitored by the experimenter. The participant flew using a partial panel with masked directional instruments (i.e., attitude indicator, turn coordinator, directional gyro, and automatic directional finder (ADF) indicator). The altimeter and vertical speed indicator used by the participant were backlit. The simulator turbulence level was set at a moderate level with the setting knob nonfunctional to the participant. The room containing the simulator was dark except for a dim (shielded) light used by the experimenter to set chair rotation parameters. Verbal responses by the participant were audiotaped with an audio recorder that was located behind the seat, outside of the simulator, to record verbal calls by the participant. Koss JCK/200.S infrared headsets set to volume 3 (0 to 10 range) with artificial generated engine and prop noise were worn by the participant and were used to mask outside noise to avoid external auditory inputs that could indicate a change in direction. The participant could also receive transmissions from the experimenter through the headset receivers. Once the participant was seated in the simulator, the enclosure was fully covered and outside references were not available to the participant.

**Design**

Threshold measurement design. Perception threshold values were determined by using a modified staircase procedure combined with an adaptive simple up-down method based on a threshold measurement design by Ross and Mughni (in press). The measurement was designed to provide a quick measurement with a high level of accuracy and to minimize expectancy error within the parameters of the measuring device. The threshold determination sessions were held on two separate days.
After the participant was seated in the rotating chair and the simulator closed, the chair was accelerated over a two minute period to a stabilized clockwise angular velocity. Threshold measurements were made from the rotational speed of three rotations per minute (rpm) in order to avoid any motion cues that might occur with accelerations from a stationary position. Various authors have commented on the difficulty of reliably initiating accelerated trials from zero velocity to a constant angular acceleration (Ross & Mughni, in press). The 3 rpm value was selected as the slowest rotational speed that permitted smooth acceleration and deceleration. This low rotation speed minimized any Coriolis effects and nystagmic eye movements that might occur due to angular motion (Ross & Mughni, in press). The rotational speed of 3 rpm was held constant for a two minute period before beginning the threshold measurements. Generally, participants reported sensations of motion to stop 10 to 30 seconds after the 3 rpm was reached.

An acceleration/deceleration threshold determination was carried out by initiating an acceleration/deceleration of 0.25 degrees per second\(^2\) for 10 seconds. If the participant reported a change in angular motion, the next acceleration/deceleration step was reduced by 0.05 degrees per second\(^2\). Conversely, if the participant did not detect the change, the next step was increased by 0.05 degrees per second\(^2\). The change in the rate of acceleration/deceleration in steps of 0.05 degrees/second\(^2\) for 10 seconds was continued until no response was perceived from the participant. From the last detected value of acceleration/deceleration, a reduced step value of 0.025 degrees per second\(^2\) for 10 seconds was then initiated, and if the participant detected angular motion the next step was further reduced to 0.0125 degrees per second\(^2\) and the procedure was repeated until the participant failed to detect angular motion. The final value of the last detected angular motion was considered the threshold. This first threshold value was used as the initial acceleration/deceleration change for the second threshold measurement. Acceleration and deceleration steps were alternated so as to remain at a stabilized angular velocity of approximately 3 rpm. Also, each acceleration/deceleration was initiated
without any cues present to signal the start of the acceleration/deceleration, and each acceleration/deceleration was initiated after a stabilization period of approximately one minute (± 15 seconds to prevent anticipation on the part of the participant). The procedure was continued until two acceleration and two deceleration threshold values were obtained for each session. Two acceleration (perceived as a right turn) and two deceleration (perceived as a left turn) threshold measurements could be determined within a 20 to 30 minute period. The experimenter could cross-check the time with the audio recording of the participant calling out "turning right" or "turning left", or from the computer recordings from where the participant depressed the microphone button. Separate recordings were made for each session. Mughni (1994, p. 31) provides a more detailed description of the concept for determining threshold measurements.

**Tasks assigned during perception threshold determination.** A simulated scenario was designed to approximate a real time situation in which a pilot inadvertently gets into a state of disorientation and fails to appreciate an ensuing angular velocity which would in actual flight result in a change of direction and attitude. The aim of the simulation scenario was to measure the threshold of an individual's sensitivity to detect angular motion, without visual references. The pilot flew with a partial panel, without directional and attitude instruments available. The scenario simulated a pilot flying in clouds or the natural horizon was obscured (such as in instrument meteorological conditions), while distracted with some other task and not paying attention to the attitude and directional instruments. During such a flight condition, for example, the pilot could be looking at the Instrument Approach Plates or attending to a radio call by a controller, or some distracting task, while trying to maintain an altitude in a turbulent weather condition. To simulate the task of reading an Instrument Approach Plate or a flip chart, a digital numeric display with randomly changing digits was used. Continually appearing digits on the display were monitored, and the assigned digits were called out by the pilot. To simulate turbulent weather conditions, computer generated turbulence was induced.
During this period angular motion was induced at a measured rate. The pilot was asked to indicate the change in direction as perceived by vestibular senses. The threshold or minimum angular motion perceived by the pilot was noted. Thus, the instructions for the tasks given to the participant were as follows:

1. “Report sensation of turn.” Participants were told to report any angular motion they sensed by verbally calling out “turning right” or “turning left”, while simultaneously depressing the yoke microphone button until the turning sensation ceased. Acceleration values above the individual’s threshold were sensed as right turns while deceleration values were sensed as left turns.

2. “Maintain altitude.” The participant was also required to maintain a constant altitude of 5000 feet (5000 feet was calibrated to give the most accurate altitude reading from the computer) with the help of only observing the altimeter and vertical speed indicator (VSI) as the primary instruments and making appropriate yoke inputs. The VSI was given to assist the pilot with the computer generated turbulence. The directional instruments were masked to preclude the chances of conflicting indications to the direction of motion, and to simulate the absence of visual cues for turning.

3. “Report assigned numbers on the digital display.” Additionally, participants were instructed to monitor the digital display on top of the panel in the simulator and to report a specified number when it appeared, together with the number that followed it. The single digit numbers were programmed to appear randomly on the computer-controlled LCD display. A number (0 through 9) was presented consecutively for five seconds each in a random sequence. A different sequence of numbers was displayed for each threshold measurement session. For example, during session one the participant was instructed to call out the digit 3 and the digit following it whenever 3 appeared on the display. For session two, the participant was instructed to call out the digit 7 and the digit following
whenever 7 appeared. Randomly sequenced numbers avoided patterns that could be learned, precluding anticipation within the time frame of the session. Also the change of sequence in each session precluded the chances of a learning curve within the given time frame of the sessions.

A major concern in creating the scenario and tasks was the difficulty level of the flight scenario used to evaluate the pilot's sensitivity to detect angular motion with the assigned tasks. Performance ceiling or floor effects resulting from flight tasks that are too easy or too difficult may prevent the demonstration of alcohol effects relative to control conditions (Ross & Mundt, in press). Since the skill of individual pilots differ on flight tasks within a particular flight scenario, as well as the ease with which they adapt to the different control inputs required by flight simulators, finding tasks of an appropriate difficulty level for the available pilot population was a problem. Therefore, the difficulty of the task was calibrated with the average experience of the participants under study. It was recognized that if the task increased beyond the capability or lay close to the upper cognitive limit for optimal performance of the participant, then the participant might reject the task, thereby defeating the purpose of the task. The task also had to be continuous with less demanding periods. And the taskload needed to be related to a possible real time situation.

**Alcohol and placebo administration.** The participant's Blood Alcohol Content (BAC) was tested by using a calibrated Alco-Sensor III Intoximeter (Intoximeters, Inc., St. Louis, MO). A double-blind procedure was used with alcohol administration and threshold measurements carried out in separate areas by different experimenters. Neither the experimenter measuring the threshold for angular motion nor the participant knew the alcohol condition, thus avoiding experimenter bias that might have confounded assessment of the threshold measurement. Also, the traditional placebo-controlled technique (Ross & Mundt, 1988) was used where all participants were told that they
would receive alcohol, whereas only the experimental groups actually received alcohol. After the prealcohol threshold measurements were taken on the test day (Day 2, Session 1), participants in the Alcohol group were given three drinks totaling 400 ml of alcohol and orange juice. The amount of alcohol was based on the weight of the participant with the amount of alcohol in the drinks calculated on the basis of a predicted relationship that 1 gm of alcohol per kg of body weight equals a 0.10% BAC, to result in a 0.04% BAC. The start of the second threshold determination (Day 2, Session 2) was delayed until the participant’s BAC declined to 0.04%, thus insuring that all participants were on the descending limb of the BAC curve. Participants in the Placebo group also received three drinks with the same volume totaling 400 ml, with each placebo drink containing only 3 ml of alcohol, which was floated on the top of the orange juice to provide an alcohol odor. After consuming a series of three drinks the Alcohol participants’ mean BAC immediately before entering the experimental apparatus (Session 2) was 0.038% (range 0.037% to 0.039%); thus, the participants were all under the FAA’s 0.04% legal limit during the test session. The mean BAC immediately after exiting the experimental apparatus (approximately 15 minutes later) was 0.028% (range 0.027% to 0.031%) as seen in Table 1 (Appendix B). After the threshold values were obtained, the participant returned to the waiting area where BAC tests were conducted every 15 minutes. Participants in both groups were permitted food snacks and soft drinks during this period. When a 0.00% BAC reading was obtained, the third set of threshold measurements was taken (Day 2, Session 3). Placebo and Alcohol participants were treated in an identical manner with BAC tests made at the same times and intervals. The mean waiting period for the participant’s BAC to reach zero after the threshold determination for Session 2 was 142.5 minutes (range 105 to 180) for Alcohol participants (see Table 1, Appendix B). The Placebo participants were also given a mean waiting period of 142.5 minutes (range 105 to 180). For Placebo participants, the interval between the second and third threshold sessions equaled the mean time required by those Alcohol participants who were tested
prior to that time to reach a zero BAC. After the final threshold determination session (Day 2, session 6), a CMI, Inc. Intoxilyzer 5000, which measures blood alcohol content (BAC) in terms of an infrared energy absorption technique, gave a printout of zero to ensure the participant was legal to drive home. The participants were also reminded not the fly because of the FAA’s eight-hour "bottle to throttle" rule.

**Procedures**

It was observed in a practice study phase of the experimental design that thresholds were affected by alcohol (at 0.04%) with two of the practice participants’ thresholds remaining elevated for three hours post alcohol. The original design included 10 sessions with (5) one-hour increments after the BAC returned to 0.00%, but subsequent testing with the practice participants showed the thresholds returned to their original value within three hours after the BAC was 0.00%. Thus, it was decided to eliminate the last two sessions from the design and only test for three additional hours (with readings taken every hour) post alcohol once the BAC level reached zero. Therefore, the design consisted of eight experimental sessions in all covering two days (Day 1 included two threshold measurement sessions and Day 2 consisted of six threshold measurement sessions, referred to in Table 2).

**Day 1.** Each participant read and signed a consent form (see Appendix C), and each participant completed a medical form, the Michigan Alcohol Screening Test (see Appendix D), and a brief version of the Quantity-Frequency-Variability alcohol questionnaire combined with a questionnaire concerning the manner the participant thinks the alcohol affects pilot performance (see Appendix A).

The participant’s blood alcohol content (BAC) was then tested by using a calibrated Alco-Sensor III Intoximeter to verify that the participant was not under the influence of alcohol before beginning the study which might affect initial threshold measurements. A video tape (7 minutes and 23 seconds in length) produced by the experimenter was then shown to the participant which familiarized him/her with the
equipment, gave a general overview of the experiment, and gave the necessary instructions to perform the specific tasks and procedures required for the experiment along with the schedule for Day 1 of the experiment.

Threshold values were then determined (referred to as Day 1, session 1) as described previously. The participant was presented with an angular stimulus (acceleration or deceleration) for a ten second duration. If the response was acknowledged (i.e., detection of angular movement), the rate of the stimulus was decreased, and if the stimulus was not acknowledged, the rate of the stimulus was increased. The participant’s threshold was determined within a 30 minute period and confirmed by at least two consistent readings. After obtaining two threshold values for acceleration and two for deceleration, the participant was given a rest period of 10 minutes in another room, followed by an additional session with two additional acceleration and deceleration threshold determinations (referred as Day 1, Session 2) to ensure consistency in the participants’ thresholds.

After the second threshold determination session the participant was given a list of "do’s and don’ts" to follow prior to Day 2. The list included eating a normal dinner the night before without alcoholic drinks, consuming no alcohol following dinner, abstaining from food and drinks except for water after midnight, and skipping breakfast the day of the appointment (refer to Appendix E).

**Day 2.** On the second day of the experiment, participants arrived between 8:00 and 8:30 AM, were weighed on a Novus Electronics digital scale, questioned about the time and the type of food consumption the night before, and given a breath test to confirm that the blood alcohol content (BAC) was 0.00%. Female participants were given a pregnancy test (an over-the-counter test giving instantaneous results) under the supervision of a female experimenter.

The participant was then taken to the experimental room for a threshold measurement (Day 2, Session 1) by starting from a predetermined average threshold
measurement from Day 1, to reconfirm the participant’s threshold and to ensure consistency; thus two threshold measurements were made under both acceleration and deceleration conditions using the same procedures as those used during Day 1.

Alcohol or placebo drinks were then administered as described earlier. Each participant in the experimental group received three drinks totaling 400 ml of 153 proof grain alcohol mixed with orange juice. Threshold measurements were taken as soon as the participant’s BAC was slightly less than 0.04%. This measurement is referred to as Day 2, Session 2. After Session 2 the participants were permitted to eat and consume non-alcoholic beverages. They could also watch videos, do homework, read, play computer games, or just relax quietly during the waiting period for their BAC level to return to zero (the participants were unaware of the reason for the waiting period). BAC readings were taken every 15 minutes until the BAC level reached zero.

Threshold measurements were again taken after the BAC reached zero (Day 2, Session 3). And again, threshold measurements were taken in one-hour increments after BAC reached zero for three consecutive hours (Day 2, Sessions 4, 5, and 6).

Following the last threshold determination, each participant was given two post-experiment questionnaires to fill out; the first questionnaire asked the participant to estimate the number of drinks consumed (equivalent to the number of the participant’s favorite alcohol drink) and to comment on flight performance in the simulator after drinking the alcohol by rating, on a five-point scale, his/her ability to hold altitude, the effort required to hold altitude, the degree of sense of movement, and the effort required to sense movement during Day 2, Session 2 (see Appendix F). The second questionnaire determined if the participant had experienced any physiological discomfort: malaise, nausea, drowsiness, increased salivation, dizziness, sweating, increased warmth, headache, and/or epigastric discomfort for Day 2, Sessions 1, 2, and 3 (see Appendix G).
After the participant completed the two questionnaires, a final BAC reading was taken by using a CMI, Inc. Intoxilyzer 5000 which gave a printout of the BAC level of 0.00%. Shortly thereafter, each participant was permitted to leave the test site.

Table 2

*Experiment Day 1 and Day 2 Schedule of Activities, Time Required, and Objectives*

<table>
<thead>
<tr>
<th>Session</th>
<th>Approximate Time (minutes)</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Check-in</td>
<td>30</td>
<td>Protocol, General Consent, and Prequestionnaires</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>Threshold Determination</td>
</tr>
<tr>
<td>Break</td>
<td>10</td>
<td>Relaxation Period</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>Threshold Confirmation</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.5 hours</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session</th>
<th>Approximate Time (minutes)</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Check-in</td>
<td>15</td>
<td>Weight, Pregnancy Test, BAC Test, Meal Query</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>Threshold Measurement (PreBAC)</td>
</tr>
<tr>
<td>Drinks</td>
<td>90</td>
<td>Alcohol Administration</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>Threshold Measurement (BAC &lt; 0.04%)</td>
</tr>
<tr>
<td>Snacks/Relax</td>
<td>120 to 180</td>
<td>Waiting Period for BAC to return to 0.00%</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>Threshold Measurement (BAC 0.00%)</td>
</tr>
<tr>
<td>Break</td>
<td>60</td>
<td>Post BAC 0.00% + 1 Hour</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>Threshold Measurement (Post BAC + 1 hour)</td>
</tr>
<tr>
<td>Break</td>
<td>60</td>
<td>Post BAC 0.00% + 2 Hours</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>Threshold Measurement (Post BAC + 2 hours)</td>
</tr>
<tr>
<td>Break</td>
<td>60</td>
<td>Post BAC 0.00% + 3 Hours</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>Threshold Measurement (Post BAC + 3 hours)</td>
</tr>
<tr>
<td>Questionnaires</td>
<td>5</td>
<td>Participant Self Analysis</td>
</tr>
<tr>
<td><strong>Total Time</strong></td>
<td><strong>10 hours</strong></td>
<td></td>
</tr>
</tbody>
</table>
Chapter Three

RESULTS

Pretreatment Consistency and Equivalency

Threshold Consistency

**Acceleration.** The mean acceleration threshold values measured on Day 1 for the Alcohol and Placebo groups were compared with the initial threshold reading on Day 2 (Session 1) for consistent patterns to check the adequacy of stability. The mean threshold values of the Alcohol and Placebo groups, respectively, were 0.474 and 0.425 degrees per second² on Day 1 and 0.473 and 0.403 degrees per second² on Day 2 (Session 1). The pattern of means for Alcohol (versus Placebo) and Day 1 (versus Day 2) did not show a significant interaction effect with a two-factor analysis of variance (ANOVA), $F(1,10) = 0.300, p > 0.50$. Also, when considered individually, the means for Day 1 and Day 2 did not differ significantly for either Alcohol or Placebo groups (all $p$ values $> 0.50$). Thus the pattern of accelerated threshold values on Day 1 and Day 2 were not different, and therefore both groups were stable.

**Deceleration.** The mean deceleration threshold values measured on Day 1 for the Alcohol and Placebo groups were also compared with the initial threshold reading on Day 2 (Session 1) for consistent patterns to check the adequacy of stability. The mean threshold values of the Alcohol and Placebo groups, respectively, were 0.571 and 0.527 degrees per second² on Day 1 and 0.583 and 0.498 degrees per second² on Day 2 (Session 1). The pattern of means for Alcohol (versus Placebo) and Day 1 (versus Day 2) did not show a significant interaction effect with a two-factor analysis of variance (ANOVA), $F(1,10) = 0.604, p = 0.46$. Also, when considered individually the means for Day 1 and Day 2 did not differ significantly for either Alcohol or Placebo groups (all $p$ values $> 0.50$). Thus the pattern of decelerated threshold values on Day 1 and Day 2 were not different, and therefore both groups were stable.
Equivalency of Thresholds for Alcohol and Placebo Pretreatment

**Acceleration.** The Alcohol and Placebo groups were assessed for equivalency of acceleration thresholds based on their initial numerical value and it was expected that the Alcohol (versus Placebo) pretreatment acceleration thresholds (Day 2, Session 1) would not differ numerically (refer to Table 4 in Appendix H and Table 5 in Appendix I). A Wilcoxon T test, $T (N = 6) = 9, p > 0.05$, showed no significant difference in the Alcohol and Placebo groups' acceleration threshold values for the prealcohol session.

**Deceleration.** The Alcohol and Placebo groups were also assessed for equivalency of deceleration thresholds based on their initial numerical value and, again, it was expected that the Alcohol (versus Placebo) pretreatment deceleration thresholds (Day 2, Session 1) would not differ numerically (refer to Appendixes H and I). A Wilcoxon T test, $T (N = 6) = 9, p > 0.05$, showed no significant difference in the Alcohol and Placebo groups' deceleration threshold values for the prealcohol session.

**Treatment**

**Thresholds**

Threshold values were measured in degrees per second$^2$, with an increase in threshold value meaning a decrement in sensitivity to angular motion. The mean threshold values for the Alcohol and Placebo participants when averaged over Acceleration (versus Deceleration) and the six Sessions were 0.564 and 0.456, respectively, and are shown in Table 3 below. These means did not differ significantly with a main effect from a three-way mixed analysis of variance (ANOVA) involving the between subjects factor of alcohol (versus placebo), and the repeated measures factor of sessions and acceleration (versus deceleration), $F(1,10) = 0.565, p = 0.47$.

The mean Acceleration (versus Deceleration) threshold values, when averaged over the Alcohol (versus Placebo) groups and all six Sessions, were 0.442, and 0.577, respectively. These means did differ significantly with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the
repeated measures factor of sessions and acceleration (versus deceleration), $F(1,10) = 6.305, p = 0.03$ (see Figure 2).

![Figure 2. Acceleration and deceleration threshold values when averaged over Alcohol (versus Placebo) groups and Sessions.](image)

The mean threshold values for Sessions 1, 2, 3, 4, 5, and 6, when averaged over Alcohol (versus Placebo) and Acceleration (versus Deceleration), were 0.489, 0.545, 0.501, 0.497, 0.509, and 0.518, respectively, and are shown in Table 3. These means did not differ significantly with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(5,50) = 1.736, p = 0.14$. Thus the threshold measurements of the Sessions did not differ significantly when averaged over Acceleration (versus Deceleration) and Alcohol (versus Placebo) groups.

The pattern of means for Alcohol (versus Placebo), Acceleration (versus Deceleration), and Sessions (refer to Table 3) did not show a significant overall interaction with a main effect from a three-way mixed ANOVA involving the between
subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(2,20) = 0.302, p > 0.50$.

The pattern of means for Alcohol (versus Placebo) and Acceleration (versus Deceleration) were 0.493, 0.634, 0.391, and 0.521, respectively. These means did not show a significant interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(1,10) = 0.011, p > 0.50$.

The pattern of means for Acceleration (versus Deceleration) and Sessions were 0.438, 0.468, 0.425, 0.423, 0.449, 0.449, 0.541, 0.621, 0.576, 0.570, 0.569, and 0.587, respectively. These means did not show a significant interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(5,50) = 0.998, p > 0.429$.

And the pattern of means for Alcohol (versus Placebo) and Sessions were 0.528, 0.639, 0.544, 0.551, 0.560, 0.560, 0.451, 0.450, 0.457, 0.443, 0.458, and 0.475, respectively. These means did not show a significant interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(5,50) = 1.873, p > 0.12$.

When considered individually by the alcohol condition, differences in Sessions were found. The mean Acceleration and Deceleration threshold values for the Alcohol and Placebo groups when measured for each Session are listed in Table 3.
### Table 3

**Mean Acceleration and Deceleration Thresholds**

| Condition | Sessions (S) | Marginal Means
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1 (pre)</td>
<td>S2 (BAC)</td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.473</td>
<td>0.552</td>
</tr>
<tr>
<td>Deceleration</td>
<td>0.583</td>
<td>0.725</td>
</tr>
<tr>
<td>Placebo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.403</td>
<td>0.383</td>
</tr>
<tr>
<td>Deceleration</td>
<td>0.498</td>
<td>0.518</td>
</tr>
<tr>
<td>Marginal Means</td>
<td>0.489</td>
<td>0.545</td>
</tr>
</tbody>
</table>

**Note.** Mean acceleration and deceleration threshold values for Alcohol/Placebo groups and Sessions are measured in degrees per second squared.

It was hypothesized that, for the Alcohol group, Session 2 would have a significantly higher threshold values than Session 1, and Sessions 3, 4, 5, and 6 would have significantly higher threshold values than Session 1 but as a decaying function of Session 2. For mean acceleration threshold values, Session 2 (m = 0.552) of the Alcohol group was significantly higher than Session 1 (m = 0.473) when tested as a planned comparison, $F(1,10) = 5.899$, $p = 0.03$. However, Session 3 (m = 0.464) for the Alcohol group was actually lower than Session 1 (m = 0.473). Session 4 (m = 0.473) produced the same value as Session 1 (m = 0.473), and Sessions 5 (m = 0.498) and 6 (m = 0.487) were higher but at a nonsignificant level ($p$ values > 0.50). Thus, the hypothesis was only partly supported with Session 2 higher than Session 1. Session 3 actually produced lower threshold values than Session 1. Sessions 4, 5, and 6 showed no significant difference in threshold values from Session 1. In contrast the Placebo group, who experienced the identical experimental procedures except for the absence of alcohol in their drinks, showed a stable acceleration threshold value for all 6 sessions and thus did not produce any significant differences between the sessions (all $p$ values > 0.37). Individual
threshold measurements of the Alcohol and Placebo participants for all the sessions are given in Table 4-Appendix H and Table 5-Appendix I.

For mean deceleration threshold values it was also hypothesized that, for the Alcohol group, Session 2 would have significantly higher threshold values than Session 1, and Sessions 3, 4, 5, and 6 would have significantly higher threshold values than Session 1 but as a decaying function of Session 2. Session 2 ($m = 0.725$) for the Alcohol group was significantly higher than Session 1 ($m = 0.583$) when tested as a planned comparison, $F(1,10) = 15.764$, $p = 0.00$. Also, Session 3 ($m = 0.625$) for the Alcohol group was significantly higher than Session 1 ($m = 0.583$), $F(5,25) = 5.951$, $p = 0.03$. Session 4 ($m = 0.628$), Session 5 ($m = 0.498$), and Session 6 ($m = 0.622$) all also produced a higher value than Session 1 ($m = 0.473$) but at a nonsignificant level (all $p$ values $> 0.18$). Thus, the hypothesis was only partly supported with Sessions 2 and 3 higher than Session 1. Sessions 4, 5, and 6 showed no significant difference in threshold value from Session 1 (prealcohol). In contrast the Placebo group, who experienced the identical experimental procedures except for the absence of alcohol in their drinks, showed a stable deceleration threshold value for all 6 sessions and thus did not produce any significant differences between the Sessions (all $p$ values $> 0.11$).

In summary, when averaged over Sessions and Acceleration (versus Deceleration), the pilots who were given Alcohol did not differ in threshold measurements from those given a Placebo. Also, the Sessions did not differ when averaged over both the Alcohol and Placebo groups and Acceleration (versus Deceleration). However, Acceleration (versus Deceleration) threshold values did differ when averaged over the Alcohol and Placebo groups for all six Sessions. None of the interactions were significant. When considered individually by the alcohol condition, differences in Sessions were found. As hypothesized, for the Alcohol group with acceleration threshold values, Session 2 (alcohol $< 0.04\%$) produced significantly higher acceleration threshold values than Session 1 (prealcohol), but Sessions 3 (post alcohol), 4
(+1 hour post alcohol), 5 (+2 hours post alcohol), and 6 (+3 hours post alcohol), did not significantly differ from Session 1. In contrast, the Placebo group showed a stable mean threshold value for all Sessions. For the Alcohol group with deceleration threshold values, Session 2 (alcohol < 0.04%) produced significantly higher threshold values than Session 1 (pre-alcohol), and Session 3 (post alcohol) continued to show significant elevated threshold values compared to Session 1 (as a decaying function of Session 2). However, Sessions 4 (+1 hour post alcohol), 5 (+2 hours post alcohol), and 6 (+3 hours post alcohol), although producing higher values, did not significantly differ from Session 1. Thus, for the Alcohol group, the deceleration threshold values increased substantially (at least 30%) after ingesting alcohol (Session 2) and decreased only slightly when tested after each participant's BAC had reached 0.00% (Session 3). However, after one, two, and three hours post alcohol, the mean thresholds had returned to their initial pre-alcohol level (Session 1). In contrast, again the Placebo group showed a stable mean threshold value for all Sessions (refer to Appendixes H and I).

To examine further for comparable results to previous studies by Ross and Mughni (in press) and Mughni (1994), a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of Sessions 1, 2, and 3 and Acceleration (versus Deceleration) was used. The means for Alcohol (versus Placebo), when averaged over Acceleration (versus Deceleration) and Sessions, were 0.570 and 0.453, respectively, and these means did not differ significantly, $F (1,10) = 0.595, p = 0.46$. The means for Acceleration (versus Deceleration), when averaged over Alcohol (versus Placebo) and Sessions, were 0.444 and 0.580, and these means differed significantly, $F (1,10) = 7.096, p = 0.02$. The means for Sessions 1, 2, and 3, when averaged over Alcohol (versus Placebo) and Acceleration (versus Deceleration) were 0.489, 0.545, and 0.501, respectively, and these means differed significantly, $F (2,20) = 6.856, p = 0.00$. 
The pattern of means for Alcohol (versus Placebo), Acceleration (versus Deceleration), and Sessions are seen in Table 6. These means did not show a significant overall interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(2,20) = 0.265, p > 0.50$.

Table 6

Mean Acceleration and Deceleration Threshold Values of Alcohol/Placebo Groups for Three Sessions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Sessions (S)</th>
<th>Marginal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1 (pre)</td>
<td>S2 (BAC)</td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.473</td>
<td>0.552</td>
</tr>
<tr>
<td>Deceleration</td>
<td>0.583</td>
<td>0.725</td>
</tr>
<tr>
<td>Placebo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.403</td>
<td>0.383</td>
</tr>
<tr>
<td>Deceleration</td>
<td>0.498</td>
<td>0.518</td>
</tr>
<tr>
<td>Marginal Means</td>
<td>0.489</td>
<td>0.545</td>
</tr>
</tbody>
</table>

Note. Mean acceleration and deceleration threshold values for Alcohol (versus Placebo) groups and Sessions are measured in degrees per second squared.

The pattern of means for Alcohol (versus Placebo) and Acceleration (versus Deceleration) were 0.497, 0.644, 0.391, and 0.515, respectively. These means did not show a significant interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(1,10) = 0.055, p > 0.50$.

The pattern of means for Acceleration (versus Deceleration) and Sessions were 0.438, 0.468, 0.425, 0.541, 0.621, and 0.576, respectively, and these means did not show
a significant interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of Sessions and Acceleration (versus Deceleration), $F(2,20) = 2.174$, $p > 0.14$.

The pattern of means for Alcohol (versus Placebo) and Sessions were 0.528, 0.639, 0.544, 0.451, 0.450, and 0.457. These means did show a significant interaction effect with a main effect from a three-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions and acceleration (versus deceleration), $F(2,20) = 7.608$, $p = 0.00$ (see Figure 3).

![Figure 3](image)

*Figure 3.* Interaction of Alcohol/Placebo groups and Sessions for the average threshold values.

When considered individually by the alcohol condition, differences in Sessions were found. The Acceleration (versus Deceleration) factor was eliminated, and the acceleration and deceleration thresholds were averaged to retain consistency with the Ross and Mughni (in press) and Mughni (1994) studies. The means for the average
threshold values of the Alcohol and Placebo groups for the Sessions are shown in Table 7.

Table 7

**Mean Threshold Values of Alcohol/Placebo Groups for Three Sessions**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Sessions (S)</th>
<th>Marginal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1 (pre)</td>
<td>S2 (BAC)</td>
</tr>
<tr>
<td>Alcohol</td>
<td>0.528</td>
<td>0.639</td>
</tr>
<tr>
<td>Placebo</td>
<td>0.451</td>
<td>0.450</td>
</tr>
<tr>
<td>Marginal Means</td>
<td>0.489</td>
<td>0.545</td>
</tr>
</tbody>
</table>

*Note.* Mean threshold values for Alcohol/Placebo groups and Sessions are measured in degrees per second squared.

For the Alcohol group, Session 2 produced significantly higher threshold values than Session 1 (prealcohol), $F(1, 10) = 15.849, p = 0.00$. However, in contrast to the Ross and Mughni (in press) and Mughni (1994) studies, Session 3 (post alcohol) did not significantly differ from Session 1, $F(1, 10) = 2.779, p = 0.06$, one-tailed, and therefore did not continue to show significant elevated threshold values compared to the prealcohol session. Thus, for the Alcohol group, the threshold values increased substantially (at least 30%) after ingesting alcohol (Session 2) but decreased to their initial prealcohol level when tested after each participant’s BAC had reached 0.00% (Session 3). In contrast, the Placebo group showed a stable mean threshold value for all Sessions (all $p$ values $> 0.50$).

In summary, when averaged over the three Sessions and Acceleration (versus Deceleration), the pilots who were given Alcohol did not differ in threshold measurements from those given a Placebo. However, Acceleration (versus Deceleration)
threshold values did differ when averaged over the Alcohol and Placebo groups for the three Sessions, but the factor did not interact with any other factor and thus was eliminated to maintain consistency with the Ross and Mughni (in press) and Mughni (1994) studies. Also, the Sessions did differ when averaged over both the Alcohol and Placebo groups and the average thresholds. However, the only significant interaction found was with Alcohol (versus Placebo) and Sessions. Again, when considered individually by the alcohol condition, differences in the three Sessions were found. For the Alcohol group, Session 2 produced significantly higher threshold values than Session 1, but Sessions 3 (post alcohol) did not significantly differ from Session 1 (prealcohol). Thus, for the Alcohol group, the threshold values increased substantially (at least 30%) after ingesting alcohol (Session 2) but decreased to their initial prealcohol level when tested after each participant's BAC had returned to 0.00% (Session 3). In contrast, the Placebo group showed a stable mean threshold value for all Sessions.

**False Positives (FP)**

Table 8

<table>
<thead>
<tr>
<th>Mean False Positives</th>
<th>Sessions (S)</th>
<th>Marginal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>S1</td>
<td>S2</td>
</tr>
<tr>
<td>Alcohol</td>
<td>0.33</td>
<td>0.17</td>
</tr>
<tr>
<td>Placebo</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Marginal Means</td>
<td>0.25</td>
<td>0.17</td>
</tr>
</tbody>
</table>

*Note.* Mean number of false positives for Alcohol/Placebo groups and Sessions is measured per minute of rotation.

When averaged over Sessions, the mean number of False Positives (see Glossary) per minute of rotation for Alcohol and Placebo participants (refer to Table 8) did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of
sessions, $F(1,10) = 1.052, p = 0.33$. When averaged over both the Alcohol and Placebo groups, the mean number of False Positives for the six Sessions (see Table 8) did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 0.186, p > 0.50$. Also, the pattern of means for Alcohol (versus Placebo) groups and Sessions did not show a significant interaction from a two-way ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 0.711, p > 0.50$. Thus the relative number of False Positives during the Sessions was not affected by the alcohol. Individual False Positives of the Alcohol and Placebo participants are shown in Table 9 of Appendix J.

**Altitude Maintenance and Altitude Control Input**

*Altitude maintenance (at 5000 feet).*

**Table 10**

*Root Mean Square Altitude Error*

<table>
<thead>
<tr>
<th>Condition</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>Marginal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>50.84</td>
<td>40.97</td>
<td>43.19</td>
<td>45.69</td>
<td>37.52</td>
<td>41.04</td>
<td>43.21</td>
</tr>
<tr>
<td>Placebo</td>
<td>44.98</td>
<td>65.59</td>
<td>44.65</td>
<td>44.27</td>
<td>40.10</td>
<td>39.27</td>
<td>46.48</td>
</tr>
<tr>
<td>Marginal Means</td>
<td>47.91</td>
<td>53.28</td>
<td>43.92</td>
<td>44.98</td>
<td>38.81</td>
<td>40.15</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Mean altitude error for Alcohol/Placebo groups and Sessions is measured in feet by root mean square (RMS) method.

Accuracy in maintaining altitude was examined by computing each participant’s mean altitude error (RMS, root mean square). The pilot’s altitude was sampled every 200 milliseconds during each session. Mean altitude error values (measured on a scale of 10-feet equaling one-half of the altimeter scale’s minimum graduation) for Alcohol and Placebo participants, when averaged over Sessions, respectively, are shown in Table 10.
These means did not differ significantly a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(1,10) = 0.192, p > 0.50$. When averaged over the Alcohol and Placebo groups, the mean altitude error (RMS measured in feet) for the six Sessions (see Table 10) did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 1.789, p = 0.13$. The mean altitude error of the pilots for the Alcohol and Placebo groups when measured for all six Sessions on Day 2 are shown in Table 10. The pattern of means for Alcohol (versus Placebo) and Sessions did not show a significant interaction effect with a two-way ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 1.88, p = 0.11$. Thus the relative ability to maintain altitude for the Sessions was not affected by the alcohol.

**Altitude control input (yoke position for elevator control).**

Table 11

*Mean Altitude Control Input*

<table>
<thead>
<tr>
<th>Condition</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>Marginal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>22.80</td>
<td>23.23</td>
<td>25.32</td>
<td>19.22</td>
<td>26.92</td>
<td>29.17</td>
<td>24.45</td>
</tr>
</tbody>
</table>

*Note.* Mean altitude control (yoke) input for Alcohol (versus Placebo) groups and Sessions is in standard deviation.

Altitude control input variability was calculated by computing each participant’s yoke position (standard deviation), which was sampled every 200 milliseconds during each session. Mean altitude control input (measured in standard deviation), when averaged over Sessions for Alcohol and Placebo participants, are seen in Table 11. While
input variability of the Alcohol group was slightly more than the Placebo group over Sessions, these means did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(1,10) = 0.374, p > 0.50$. When averaged over the Alcohol and Placebo group, the mean altitude control input (measured in standard deviation) for the six Sessions (seen in Table 11) did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 0.829, p > 0.50$. The mean altitude control input (measured in standard deviation) of the pilots for the Alcohol and Placebo groups, when measured for all six Sessions on Day 2, are seen in Table 11. The pattern of means for Alcohol (versus Placebo) and Sessions did not show a significant interaction effect with a two-way ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 0.608, p > 0.50$. Thus the relative effectiveness of altitude control input for the Sessions was not affected by the alcohol.

**Digits Missed**

Table 12

*Mean Digits Missed*

<table>
<thead>
<tr>
<th>Condition</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>Marginal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>0.33</td>
<td>0.17</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.08</td>
</tr>
<tr>
<td>Placebo</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.17</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>Marginal Means</td>
<td>0.17</td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td>0.08</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Mean number of digits missed for Alcohol/Placebo groups and Sessions is measured out of approximately 180 digits per session.

When averaged over Sessions, the mean number of Digits Missed (out of approximately 180 digit presentations per session) for Alcohol and Placebo participants
(see Table 12) did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(1,10) = 1.429, p = 0.26$. When averaged over both the Alcohol and Placebo groups, the mean number of Digits Missed for the six Sessions (see Table 12) did not differ significantly with a main effect from a two-way mixed ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 1.064, p = 0.39$. The mean number of Digits Missed for the Alcohol and Placebo when measured for Session 1, Session 2, Session 3, Session 4, Session 5, and Session 6, are seen in Table 12. The pattern of means for Alcohol (versus Placebo) groups and Sessions did not show a significant interaction effect a two-way ANOVA involving the between subjects factor of alcohol (versus placebo) and the repeated measures factor of sessions, $F(5,50) = 1.702, p = 0.15$. Thus the relative ability to identify the digits during the Sessions was not affected by the alcohol.

In summary, when averaged over Sessions, the pilots who were given Alcohol did not differ in the number of Digits Missed from those given a Placebo. Also, the number of Digits Missed for all Sessions did not differ when averaged over both the Alcohol and Placebo groups. Thus, most participants in the Alcohol and Placebo groups correctly reported all of the assigned target digits when displayed. Only three participants in the Alcohol group did not report one digit out of the 180 digits presented for Sessions 1 and 2. All of the Alcohol participants correctly reported the digits for Sessions 3, 4, 5 and 6. Only one participant in the Placebo group did not correctly report one of the assigned target digits when displayed during Session 5. However, all of the Placebo participants correctly reported the digits for Sessions 1, 2, 3, 4, and 6 (see Table 13 in Appendix K).
Questionnaires

Prequestionnaires

Both the Alcohol and Placebo participants’ ratings of how alcohol might affect pilot performance were quite similar. Average sums over all nine tasks of how the effect of one or two drinks would affect the flight tasks (scored as -2 much worse, -1 somewhat worse, 0 no effect, 1 somewhat better, and +2 much better) were -6.5 and -10.5, respectively, for the Alcohol and Placebo participants. A Wilcoxon T test, \( T (N = 6) = 2.5, p > 0.05 \), showed the Alcohol and Placebo participants did not differ in their ratings. When using a t Test for Dependent Samples, \( t (5) = -4.044, p = 0.01 \), both did differ from the no effect. Thus, the Alcohol and Placebo participants thought that alcohol had some overall negative effects on specific flight tasks.

Post Questionnaires

After the final threshold determination (Session 6), participants filled out two questionnaires; one asked the participants to estimate the number of drinks consumed and to estimate performance on various tasks, while the second questionnaire was concerned with discomfort symptoms experienced during sessions 1, 2, and 3. The individual ratings are given in Appendixes L, M, and N.

Post Questionnaire No. 1. In their responses to the post-experimental questionnaire concerned with the amount of alcohol consumed and its effects, the Alcohol participants estimated that they had received a number of alcoholic drinks ranging from 1.0 to 4.5 (mean of 2.83). Estimates by the Placebo participants ranged from 0.5 to 3.0 (mean of 2.0). Four of the six Alcohol participants, and three of the six Placebo participants, reported feeling physical effects of the drinks. Individual results from the questionnaire on perceived alcohol level and performance are shown in Table 14-Appendix L.

Performance scale ratings for holding altitude and sensing movement for Session 2 (BAC < 0.04%) were scored as follows: much worse (-2), somewhat worse (-1), same
(0), somewhat better (+1), and much better (+2). The Alcohol and Placebo participants’
average scores were, respectively, -0.17 and -0.17 for ability to hold altitude and -0.33
and -0.67 for sense of movement. Corresponding mean ratings of less or more effort
required were 0.67 and 0.33 for holding altitude and 0.00 and 0.67 for sensing movement.
A Wilcoxon T test, T (N = 6) = 2.5, p > 0.05, showed the Alcohol and Placebo
participants did not differ and had a similar pattern of ratings for performance on ability
to hold altitude/sense movement and effort required to hold altitude/sense movement.
When using a t Test for Dependent Samples, t (5) = -4.044, p = 0.01, both Alcohol and
Placebo participants did differ from the no effect, with both reporting that performance on
the tasks was reduced and that more effort was required to perform the tasks.

Post Questionnaire No. 2. The discomfort scale values for the discomfort level
questionnaire (see Appendixes M, Table 15 and N, Table 16) ranged from none (0) to
severe (4). Nine symptoms were included: malaise, nausea, drowsiness, increased
salivation, dizziness, sweating, increased warmth, headache, and epigastric discomfort.
Ratings were made for each symptom for three threshold measurement sessions (Day 2,
sessions 1, 2, and 3). Drowsiness was the most common discomfort symptom for all
participants.

Table 17

<table>
<thead>
<tr>
<th>Condition</th>
<th>Session 1 (prealcohol)</th>
<th>Session 2 (BAC)</th>
<th>Session 3 (post alcohol)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drowsiness</td>
<td>Other</td>
<td>Total</td>
</tr>
<tr>
<td>Alcohol</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Placebo</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
For Session 1 (prealcohol), 3 Alcohol participants reported a total of 6 symptoms (3 drowsiness, 3 other) and are shown in Table 17. 3 Placebo participants reported a total of 4 symptoms (1 drowsiness, 3 other). However, a Chi Square test showed no significant difference in the Alcohol and Placebo groups for Session 1, $X^2 (1) = 0.10$, $p = 0.747$. The level of discomfort ratings for both groups was slight to moderate with the Alcohol group indicating a slightly higher weighted level of discomfort (weighted sum of 8 versus 5).

For Session 2 (with alcohol), all 6 Alcohol participants reported a total of 15 symptoms (6 drowsiness, 9 other) and 5 of the 6 Placebo participants reported discomfort symptoms for a total of 6 (3 drowsiness, 3 other) (refer to Table 17). However, a Chi Square test showed no significant difference in Alcohol and Placebo groups for Session 2, $X^2 (1) = 3.05$, $p = 0.77$. The level of discomfort ratings for the Alcohol group ranged from slight to severe and the Placebo group ranged from slight to moderate, with the Alcohol group indicating a higher weighted level of discomfort (weighted sum of 21 versus 11).

For Session 3 (post alcohol), all 6 Alcohol participants continued to report symptoms for a total of 16 (6 drowsiness, 10 other) and 5 Placebo participants reported discomfort symptoms for a total of 5 symptoms (3 drowsiness, 2 other) (refer to Table 17). A Chi Square test showed a significant difference in Alcohol and Placebo groups for Session 3, $X^2 (1) = 4.76$, $p = 0.027$. The discomfort ratings for both groups ranged from slight to moderate, with the Alcohol group again indicating a slightly higher weighted level of discomfort (weighted sum of 23 versus 11).

When considering all combined complaints after given drinks (Sessions 2 and 3), the total number of symptoms for the Alcohol and Placebo groups, respectively, were 31.0 and 11.0. The Alcohol and Placebo groups showed a significant difference for the combined symptoms of Sessions 2 and 3 with a Chi Square test, $X^2 (1) = 8.60$, $p = 0.004$. Thus both the Alcohol and Placebo participants reported an increase in symptoms after
given drinks, with the Alcohol participants reporting significantly more than the Placebo participants. None of the Placebo participants’ ratings were above the slight to moderate range, while only one Alcohol participant reported one symptom greater than moderate in strength (drowsiness). Nonetheless, the Placebo participants (who thought on average they had two drinks, reported previously) did report an increase in the number of discomfort symptoms, suggesting the placebo drinks were effective.

This questionnaire concerning discomfort level was not completed by the participants until after Session 6 because of a concern for bias to suggest discomfort to the participant. The participants were asked to rate the level of discomfort for only Sessions 1, 2, and 3 but not until approximately three hours after Session 3. This time lapse raises a retrospective concern. It is possible that the participants may have answered based on their feelings going in to each session or they may have speculated on how long they thought their BAC level decreased. Also, the participants may have been bored or may have confused the session.
Chapter 4

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Discussion

The overall mean threshold value for Alcohol participants before they received alcohol was 0.528 degrees per second\(^2\) (range from 0.194 to 0.911) and 0.451 degrees per second\(^2\) for Placebo participants (range from 0.240 to 0.910). A large number of studies have been conducted to determine the threshold for perception of angular motion. Clark (1967) surveyed 21 studies that reported angular motion thresholds obtained under widely differing procedures and found values between 0.0350 degrees per second\(^2\) and 8.200 degrees per second\(^2\). Howard (1986), in discussing angular motion thresholds, cited studies reporting values from 0.240 to 0.450 degrees per second\(^2\) for cupulometry measurement procedures, and means of 0.800 degrees per second\(^2\) (range from 0.230 to 2.00) and 0.440 degrees per second\(^2\) (range from 0.050 to 3.180) for rotating chair experiments involving first reports of rotation. Thus, it can be seen that the present results are roughly comparable to those of past studies although procedures differ to an extent that makes direct comparison difficult.

The increases in the participants’ thresholds following alcohol ingestion were substantial (mean of 30.86%). The mean threshold for Session 2 was significantly greater for Alcohol as compared to Placebo participants, with all Alcohol participants showing an increase in threshold. The Ross and Mughni study (in press) and Mughni (1994) reported that the Alcohol participants continued to show an elevated threshold after their BACs returned to zero, which occurred, on average, 2.7 hours after their peak BAC. Long lasting effects of alcohol on vestibular functioning have also been demonstrated by the occurrence of PAN as long as 48 hours after alcohol ingestion, although other measures of responses to vestibular stimulation (e.g., duration of turning sensations and nystagmic eye movements elicited by angular acceleration) have much shorter duration and do not appear to persist after a zero BAC is reached (Collins, Schroeder, Gilson, & Guedry,
For the current study, the deceleration threshold values of Alcohol participants were significantly higher than those of Placebo participants during the third test session (when BAC returned to 0.00%), but the acceleration threshold values declined to their prealcohol level. Examination of these participants' BAC curves, altitude error performance, number of false positives, and estimates of task difficulty and effort did not suggest a basis for their lowered thresholds for Session 3 (post alcohol). Thus the source of the individual differences in persistence of the alcohol threshold effect is not evident. However, the acceleration and deceleration threshold values for the Alcohol group were significantly different, and this difference may have resulted from an artifact of the simulator or unknown external cues.

One possibility with respect to alcohol's effect on the participant's threshold for detecting angular motion change is that alcohol increased the difficulty of the altitude and digit reporting tasks (i.e., perhaps acted functionally to increase workload, or resulted in discomfort symptoms such that less attention was directed toward angular motion cues). Alternatively, alcohol could affect the sensitivity of the inner ear to angular motion (e.g., through changes in the specific gravity of the endolymph).

However, the performance of Alcohol participants on the altitude and number reporting tasks does not appear to be sufficiently different from that of the Placebo group to account for the threshold differences. Further, Alcohol participants reported that more effort was required both to hold altitude and sense movement than did Placebo participants, although these Alcohol-Placebo participant differences were not statistically significant. These data, showing that Alcohol participants required as much or more effort to perceive angular motion than did the Placebo participants, do not support the notion that the increased threshold values of Alcohol participants were the result of directing attention away from the threshold task to that of maintaining altitude.
The placebo procedures were quite effective as shown by the Placebo group’s (mean) estimate of having had 2.0 drinks when in fact only a few milliliters of alcohol were floated on the tops of their orange juice drinks. In addition, their discomfort scores increased as those of the Alcohol group for Session 2. It should be noted that while the Placebo group’s discomfort scores increased for Session 2, their threshold values did not increase. For Session 3, Placebo participants’ discomfort began to decrease toward their predrink levels while the Alcohol participants’ discomfort levels continued to remain increased. Thus, to entertain the hypothesis that the threshold values of the Alcohol and Placebo participants corresponded to their discomfort levels, it would be necessary to assume that the pattern holds for actual (Alcohol participants) discomfort, but not for the perceived discomfort that results from placebo procedures.

**Conclusions**

As anticipated, the results of the study indicate that in the absence of visual cues, pilots’ thresholds for perceiving a change in angular motion were adversely affected by alcohol (by at least 30%). Surprisingly, however, when blood alcohol level returned to zero, the effect on the pilots’ thresholds only persisted within one hour post alcohol. Certain factors may mask or complicate attempts to determine the relationship between low alcohol levels and pilot performance and lead to an underestimation of alcohol effects. These factors include: variability, compensation/attention, expectancy, and simulation.

**Variability.** Difficulty in demonstrating low BAC effects on pilot performance may reflect the variability of relevant pilot characteristics and skills. Variability due to individual differences may have been a major contributor to the alcohol effect and its lack of persistence. Even with homogeneous groups of pilots assessed for flight experience, age, drinking habits, and gender, individual differences among pilots have been found to account for the majority of variance in simulator flight performance (Nolan, Hettinger, Kennedy, & Edinger, 1988; Ross & Mundt, in press). Exogenous factors such as the
individual’s drinking history, innate and acquired tolerance to alcohol, and expectations, perhaps interactively, could also contribute to performance variability.

**Compensation and Attention.** Another issue relating to variability in data may have to do with compensation. According to Ross and Mundt (in press) a compensation process can be conceptualized as a kind of focusing of attention and increase in the overall effort exerted in attempting to maintain or optimize performance. While the ability of individuals to compensate for the effects of alcohol has not been extensively investigated, some studies have demonstrated that instructional set can counteract alcohol induced performance decrements on visual-motor tasks (George, Raynor, & Nochajski, 1992; Ross & Mundt, in press), driver simulator braking tasks (Nochajski, 1993), as well as on letter cancellation and digit span (Ross & Mundt, in press). For example, it has long been recognized that the participant’s functional field of view becomes restricted after ingestion of alcohol (Moskowitz & Sharma, 1974) or an increase in central task load (Ikeda & Takeuchi, 1975). This type of process could well be operating in flight situations as a pilot compensates for alcohol effects by focusing attention on a single aspect of the overall flight task. While this could help sustain performance on the specific task attended, it could lead to dangerous neglect of other important flight information (Ross & Mundt, in press).

A compensation process could also take the form of an increase in overall effort expended to maintain acceptable performance under alcohol conditions. Participants report that comparable flight tasks require more effort after ingesting alcohol even when performance measures fail to show an alcohol decrement (Ross, Yeazel, & Chau, 1992; Ross & Mundt, in press). Thus, it appears that the compensatory factor can occur either when the experimental task is such that participants are required to focus upon a single, spatially-limited task or when there are multiple, distributed tasks to be performed, as is the case in most flight situations.
When the participant can focus on a single task at the expense of other tasks, there may be no indication of an alcohol effect unless overall workload or broader measures of performance are monitored and scored. For example, Ross and Mundt (1988) demonstrated that under alcohol conditions one navigation task (keeping a course deviation indicator centered) could be maintained quite well under low BAC conditions, but that altitude deviations from the assigned value were greater than was the case under placebo conditions. Apparently it was possible for the participants to compensate for the effects of alcohol by increasing effort until some level of task load was reached, which presumably occurred as a function of some combination of workload and inability to rely on the automatization of practiced procedures. These reports thus indicated that BACs below 0.04% impose a workload cost on the pilot, although performance effects may show only under certain combinations of circumstances in the flight environment. Ross and Mundt (in press) suggest that the necessity to monitor multiple aspects of performance in order to identify such alcohol effects has led to the use of expert-based multiattribute models of flight performance, or the simpler process of adding a number of standardized performance measures, such as z-scores, in order to obtain an overall, composite, flight performance value. With these measures, according to Ross and Mundt (in press), reallocation of effort in response to the deleterious effects of alcohol is reflected in the composite score when no decrement otherwise would be found.

These procedures may not identify alcohol effects, however, when effort levels are increased to compensate for alcohol effects across multiple distributed tasks. In these cases decrements are likely to be found only if workload limits are reached. For example if unusual or emergency conditions are encountered, fatigue or other personal conditions exist that limit the individual’s ability to cope with the situation, or the overall task difficulty is increased to a sufficiently high level.

Thus, the results from the current study suggest that even though the effects of a low BAC level are apparent under certain test conditions, the overall alcohol effect
causing a decrement in performance may have been partially masked by the participants’
attention inappropriately distributed among tasks where primary attention was allocated
to a task that was secondary in importance to flight safety. Thus the alcohol effect may
have caused a narrowing of the attentional field and this narrowing reflected a focusing of
attention on central tasks in order to compensate for the deleterious effects alcohol, which
could significantly attenuate the apparent effects of alcohol on performance (e.g.,
sensitivity to perceive angular motion). Future research may need to consider the effect
of alcohol and its duration by addressing the primacy effect of attention and related
demands in contrast to the inner ear phenomena.

**Expectancy.** In alcohol and pilot performance research the participants generally
expect to receive at least some alcohol, since informed-consent rules require that the
possibility be explicitly stated, and the placebo procedures are usually effective in
suggesting to the participant that alcohol is being consumed even when it is not. The
expectation of an alcohol decrement in a flight situation may lead to a variety of effects
including extra effort on the part of the placebo participant to compensate for anticipated
alcohol effects, or an increase in the participant’s general anxiety level that negatively
affects performance. Consequently participants could fly better or worse after receiving a
placebo drink than would otherwise be the case. According to Ross and Mundt (in press)
the placebo treatment cannot be viewed as a neutral control-condition and might be
expected to interact with other psychosocial characteristics of the pilots in its effects on
pilot performance. It should be recognized that in the "real world" of aviation,
individuals know if they have consumed alcohol prior to flight, although survey research
indicates that pilots generally underestimate the time necessary to eliminate the alcohol
from their systems after drinking (Ross & Ross, 1992b). Thus, Ross and Mundt (in
press) suggest a variation of the balanced-placebo design in which two groups of
participants would be correctly informed whether they would receive alcohol or placebo
drinks, along with two other groups of participants, alcohol and placebo, who would
remain uninformed about the content of their drinks. This type of procedure might have been more useful for the current study.

**Simulation.** System simulation makes it possible to investigate the effects of alcohol under conditions that would be difficult, if not impossible, to repeat with consistency in actual operational contexts. Investigations of alcohol effects on pilot performance have, with one exception (Billings, Wick, Gerke, & Chase, 1973), employed flight simulators. However, the degree to which simulator performance under alcohol conditions can be generalized to actual flight remains a concern. It may well be that research involving simulators underestimates the effects of alcohol. Despite that pilots can become emotionally involved in simulated flight scenarios and report stress and fatigue when difficult flight tasks are experienced, actual flight motion can affect the visual-vestibular orientation system in a manner not duplicated even in simulators with motion cueing capabilities. Actual flight situations could produce higher stress levels resulting in different alcohol effects because of the greater consequences of errors. To the extent that the G-forces and sustained motion experienced in flight produce spatial disorientation, for example in the case of somatogyral or coriolis effects, the probability would increase that even low levels of alcohol in the bloodstream would lead to serious decrements in flight performance. Other factors that might be encountered in flight such as hypoxia, fatigue, and the disorienting effects of turbulence could also have an interactive effect with low alcohol levels in impairing pilot performance. Another concern is that simulators, even highly sophisticated full-motion simulators, cannot accurately reproduce the G-forces produced in actual flight. This may be particularly important since the visual-vestibular orientation system is quite sensitive to alcohol, and alcohol effects on inner ear mechanisms could be increased under G-loading (Gibbons, 1988).
**Recommendations**

The recommendations concerning a pilot's sensitivity to angular motion with alcohol levels less than 0.04% based on the results of the current simulation study are submitted as follows:

1. For both acceleration and deceleration threshold measurements, the results showed a substantial decrement (at least 30%) in the thresholds for detection of angular motion with alcohol (< 0.04%), and with deceleration the effect even persisted a short time after the 0.00% BAC level. Thus Federal Aviation Regulation 91.17 (U.S. Office of the Federal Register, 1994) needs to be re-evaluated and the permissible BAC may need to be reduced to 0.00%. Certainly, further study with a larger sample size is recommended to confirm the results. Also, a larger research project involving various amounts of alcohol relating to a pilot's sensitivity to angular motion should be considered as an attempt to identify some trend for analysis. A practice study conducted by the present researcher found that an alcohol group of 0.06% BAC produced extremely variable threshold measurements, suggesting that drinking habits and drinking history, innate and acquired tolerance to alcohol, compensation of alcohol with workload, and individual differences among pilots all need to be considered in future research.

2. The FAA's eight-hour "bottle to throttle rule" should be reconsidered. Although the results of the current study do not support a significant residual effect, extraneous variables could have masked the effect. Minimal-waiting period rules beyond eight hours are already mandated by military, airline transport operations, and some corporations (Modell & Mountz, 1990). Certainly additional research is needed and it is suggested that attentional issues relating to residual alcohol effects as well as the inner ear phenomenon be considered.
3. In order to convince the operators about the reason for a change in the rules and regulations, the authorities need to provide a rationale for a more strict rule on the subject. A large scale educational program highlighting the hazardous effects of alcohol on pilot performance needs to be instituted at all levels to ensure willing acceptance of the rule. Pilots should be required to demonstrate their knowledge of alcohol related regulations, as well as the understanding of the effect of alcohol on short term and long term performance of a pilot. Also, regulations must have strict penalties for flying under the influence of alcohol so that violations are minimized. And effective ways to identify and rehabilitate persons with alcohol problems should be an essential component of the program both at the state and federal level.

4. As noted by Modell and Mountz (1990), however, education and regulatory approaches alone may not be sufficient to deter a pilot from flying under the influence of alcohol. For example, lack of efficacy of driver education and drunk-driving laws provide a strong argument in support of this statement (Modell & Mountz, 1990). Therefore, it is recommended that the flying institutions, corporate management, and the state and federal authorities endeavor to cultivate and foster an "alcohol free culture" in the aviation community in the larger interest of safety for all.

In summary, the results of the current study do not support the idea that BAC values under 0.04% are safe in simulated flight. Apparently even a quite low BAC can result in a decrement of a pilot’s sensitivity to angular motion and can result in pilot errors under circumstances that, while they may differ from pilot to pilot, are likely to occur under more difficult flight conditions. Certainly, additional research is required. Decrements in pilot performance such as were found in this study may not routinely place an aircraft in imminent risk of an accident, but the margin of safety would be reduced, and under
circumstances of increased demands on the pilot, it is likely that the probability of an accident would be increased significantly.
GLOSSARY

Aftereffect:
An effect or sensation that follows at some interval after the stimulus which produces it has been withdrawn.

Ampulla:
The dilated portion of a semicircular canal containing the cupula and crista.

Coriolis illusion:
An illusion involving a sensation of body rotation and an apparent motion of objects in the visual field which is caused by tilting the head about one axis while the head is undergoing passive rotation about another axis.

Cupula:
A gelatinous structure situated over and supported by the crista. The cupula forms a moving seal across the ampulla and is deflected by a flow of endolymph through the semicircular canal.

Endolymph:
Fluid contained in the semicircular canals, utricle, and saccule.

False Positive:
With reference to the experiment, False Positives are defined as an incorrect sensation of turning reported by the participant.

Habituation:
A gradual adaptation to a repeated stimulus. The adaptation involves a change in the response of the organ or organism stimulated.

Nystagmus:
Any rhythmic involuntary motion of the eyes is known as Nystagmus. Nystagmus induced or increased by head tilt is referred to as positional nystagmus. Positional nystagmus due to Alcohol ingestion is called Positional Alcohol Nystagmus or PAN.
This probably results from a disturbance of the specific gravity of the endolymph (Money & Miles, 1974).

Oculogyral illusion:

A visual illusion involving an apparent vertical movement of objects in the visual field and which is caused by a downward acceleration yielding a G vector of magnitude between 0 and 1.0; a special case of the elevator illusion.

Optokinetic:

Of or pertaining to a movement of the eye elicited by a visual stimulus as in optokinetic nystagmus.

Positional Alcohol Nystagmus (PAN):

See Nystagmus.

Proprioceptive sensations:

Sensations transmitted through non-vestibular components like muscle spindles, tendons, joints, etc.

Semicircular canal:

Any of the three curved tubular canals in the labyrinth of the ear, associated with sensing of angular motion.

Threshold:

That value at which a stimulus just produces a sensation or comes just within the limits of perception.

Vertical axis:

The axis, in the head axis system, defined by the intersection of the frontal and sagittal planes. The vertical axis is aligned with the gravitational vertical and directed downward in an erect head.

Vestibular:

Of or pertaining to the vestibule, in particular the motion sensing apparatus of the inner ear.
Vestibule:

Vestibulum auris, an oval cavity in the middle of the bony labyrinth, communicating in front with the cochlea and behind with the semicircular canals, and containing the utricle and saccule.
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Clark, B., & Stewart, J. D. (1972b). The power law for the perception of rotation by airline pilots. Perception and Psychophysics, 11, 433-436.


APPENDIX A
QUANTITY-FREQUENCY-VARIABILITY AND
ALCOHOL AFFECTING PERFORMANCE
QUESTIONNAIRE
QUANTITY-FREQUENCY-VARIABILITY AND ALCOHOL AFFECTING PERFORMANCE QUESTIONNAIRE

Part I

The following questions are concerned with the use of alcohol. Please read each question carefully before you mark your answer.

1. Do you ever drink beverages containing alcohol?
   _____ Yes (if your answer is "yes", go to the next question.)
   _____ No (If your answer is "no", skip to Part II of this questionnaire.)

2. Please check how often you have any drink containing alcohol, whether it is beer, wine, whiskey or any other drink.
   _____ 3 or more times a day
   _____ 2 times a day
   _____ Once a day
   _____ Nearly every day
   _____ 3 or 4 times a week
   _____ Once or twice a week
   _____ 2 or 3 times a month
   _____ About once a month
   _____ Less than once a month

3. When you have a drink containing alcohol, which one of the following beverages do you drink most often?
   _____ Beer
   _____ Wine or a punch containing wine
   _____ Whiskey or liquor (straight or in a mixed drink)
   _____ Other (please specify ____________________________ )

4. Think of all the times in the past year that you drank the beverage you marked in question 3 above. When you drank that beverage, how often did you have as many as five or six drinks?
   _____ Nearly every time
   _____ More than half the time
   _____ Less than half the time
   _____ Once in a while
   _____ Never
5. When you drank the beverage marked in question 3, how often did you have three or four drinks?

<table>
<thead>
<tr>
<th>Option</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearly every time</td>
<td></td>
</tr>
<tr>
<td>More than half the time</td>
<td></td>
</tr>
<tr>
<td>Less than half the time</td>
<td></td>
</tr>
<tr>
<td>Once in a while</td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td></td>
</tr>
</tbody>
</table>

6. When you drank the beverage marked in question 3, how often did you have one or two drinks?

<table>
<thead>
<tr>
<th>Option</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearly every time</td>
<td></td>
</tr>
<tr>
<td>More than half the time</td>
<td></td>
</tr>
<tr>
<td>Less than half the time</td>
<td></td>
</tr>
<tr>
<td>Once in a while</td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td></td>
</tr>
</tbody>
</table>
Part II

Please also answer the following:

1. How serious a problem is alcohol use in aviation:
   ___ no problem
   ___ a minor problem
   ___ a somewhat serious problem
   ___ a quite serious problem

2. Some pilots believe that a couple of drinks can make their flying smoother. Do you think this is:
   ___ a generally correct statement
   ___ a correct statement for some pilots
   ___ an incorrect statement for all pilots

3. How do you think the average pilot’s flying would be affected by one or two drinks? For each of the following, circle the hash mark that represents your judgment of the effect.

   a. Speed of Responses

      |--------|--------|--------|--------|--------|
      much   somewhat no    somewhat   much
      worse   worse    effect   better   better

   b. Physical Coordination

      |--------|--------|--------|--------|--------|
      much   somewhat no    somewhat   much
      worse   worse    effect   better   better

   c. Planning Ahead

      |--------|--------|--------|--------|--------|
      much   somewhat no    somewhat   much
      worse   worse    effect   better   better
d. Ability to Attend to Several Things at Once

much somewhat no somewhat much
worse worse effect better better

e. Concentration on Tasks

much somewhat no somewhat much
worse worse effect better better

f. Instrument Scan

much somewhat no somewhat much
worse worse effect better better

g. Radio Communications

much somewhat no somewhat much
worse worse effect better better

h. Physical Effort Required to Fly Well

much somewhat no somewhat much
worse worse effect better better
4. Do you think that there are some pilots whose flying performance might be improved by a small amount of alcohol?

_____ yes  _____ no

5. If you marked “Yes” for Question 4 above, please circle the letter of those flight characteristics listed below (and in Question 3) that you think might be improved (circle all that apply):

   a. Speed of Responses
   b. Physical Coordination
   c. Planning Ahead
   d. Ability to Attend to Several Things at Once
   e. Concentration on Tasks
   f. Instrument Scan
   g. Radio Communications
   h. Physical Effort to Fly Well
   i. Mental Effort to Fly Well
APPENDIX B

BAC LEVELS AND DRINKING CATEGORIES
Table 1

*BAC Levels and Drinking Categories*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Alcohol Participants</th>
<th>Placebo Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BAC at Session 2</td>
<td>BAC after Session 2</td>
</tr>
<tr>
<td>1</td>
<td>0.039</td>
<td>0.028</td>
</tr>
<tr>
<td>2</td>
<td>0.037</td>
<td>0.031</td>
</tr>
<tr>
<td>3</td>
<td>0.039</td>
<td>0.028</td>
</tr>
<tr>
<td>4</td>
<td>0.039</td>
<td>0.029</td>
</tr>
<tr>
<td>5</td>
<td>0.038</td>
<td>0.027</td>
</tr>
<tr>
<td>6</td>
<td>0.038</td>
<td>0.030</td>
</tr>
<tr>
<td>Average</td>
<td>0.038</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>BAC at Session 2</td>
<td>BAC after Session 2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<tr>
<td>5</td>
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<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Notes.* Participant numbers are given in order of their participation sequence. Waiting period is the time BAC of alcohol participants returned to zero. Drinking category is based on QFV approach developed by Cahalan, Cisin, and Crossley (1969).
APPENDIX C

CONSENT FORM
CONSENT FORM

Project: Alcohol Use and Aviation Safety

I agree to participate in a 2-day study of the effects of alcohol and disorientation on simulator flight performance. I will be asked to complete a questionnaire concerning my alcohol use, as well as a medical questionnaire. I understand that I cannot participate in the study if I am taking medication or have inner ear problems; or if I am particularly susceptible to motion sickness or discomfort. On each of the experimental days I will be asked to consume alcohol in moderate amounts that may differ each day. Several times each day breath-alcohol readings will be taken. On each day I may or may not be told how much alcohol, if any, has been included in the drinks I will be asked to consume.

I understand that while the amount of alcohol to be consumed will not be enough to make me legally intoxicated, it may be enough to impair my functioning, and I agree to stay in the waiting room of the Aviation Safety Laboratory until my blood alcohol level has decreased to a safe value, as determined by breath-alcohol measures.

Following the consumption of alcohol drinks I will be seated in the flight simulator and will be asked to engage in various flight tasks. During the experiment the simulator in which I will be seated will move in various ways such that I may feel sensations of movement that produce slight disorientation or vertigo. I understand that if this becomes unpleasant and I wish to stop, I will be permitted to do so upon my request. Following my time in the simulator I will be required to remain in the laboratory for approximately 1 to 2 hours until my blood alcohol level has decreased to a safe value.

I understand that I am free to discontinue participation in the study at any time. However, while the session itself may be discontinued, I may not leave the designated research area until my blood alcohol level has dropped to zero or near zero. If I am not selected to serve in the study, or I elect to discontinue participating, I understand that all forms I have completed will be destroyed.

I certify that I am 21 years old or older; that I do drink alcoholic beverages (i.e., that I am not an abstainer); that I am not currently attempting to abstain from drinking alcoholic beverages; that I do not have diabetes, heart problems, or epilepsy; that I am not taking any medication or drugs listed on the attached page and that I am not particularly susceptible to motion sickness or discomfort.
I understand that no risks or discomforts are expected, other than those that normally occur on occasion from consuming alcoholic beverages. I further understand that all information about my participation in this study will be kept confidential, with only those directly involved in the study having access to the material. If I do not participate in the experiment, all screening documents containing personal information will be destroyed. Any published reports will present only statistical data or individual data without personal identification.

A preliminary description of the project has been given to me in person. I understand that I am free to ask questions about the procedures to be used, and at the end of the session, I will be fully informed as to the purpose of the research project. I also understand that the experiment is expected to have no direct benefit to me personally, but that the results will be used to further scientific knowledge about alcohol and its effects on pilot performance.

I understand that the experiment will take 2 hours on Day 1, and either a half-day or a full day on Day 2. Also, I will be paid a total of $10 for Day 1, and either $30 if I am in the half-day group or $60 if I am here for the full day (8 a.m. - 6 p.m.) on Day 2.

If you have any questions or comments, please discuss them with those involved in the study, and/or contact Dr. L. E. Ross, Center for Aviation/Aerospace Research, (904) 226-7108.

Name (print) ___________________________ S.S.# ___________________________
Signature ______________________________ Date _____
Address ________________________________

Telephone ______________ Age _______ Gender _______
Total flight hours ___________ Total simulator hours _______________
Total hours PIC in:

The last 30 days  ________________
The last 90 days  ________________
The last six months ________________

How many total time hours have you logged per year for each of the past three years?

__________________________________________________________________________

__________________________________________________________________________

Are you presently current in terms of your rating(s)? Please explain. ________________

__________________________________________________________________________

__________________________________________________________________________

Aircraft/Simulator flown (make & model, or type, and hours) ________________

__________________________________________________________________________
APPENDIX D

MICHIGAN ALCOHOL SCREENING TEST (MAST)
MICHIGAN ALCOHOL SCREENING TEST (MAST)

The Federal agency supporting this research project requires that we ask you to respond to the questions below before you can be given alcohol. The results will be kept completely confidential and your name will not appear on the form or be linked with your answers.

Please circle the response which best applies to you. The results from this survey will be kept completely confidential.

1. Do you feel you are a normal drinker? Yes No
2. Have you ever awakened the morning after some drinking the night before and found that you could not remember a part of the evening before? Yes No
3. Does your spouse (or parents) ever worry or complain about your drinking? Yes No
4. Can you stop drinking without a struggle after one or two drinks? Yes No
5. Do you ever feel bad about your drinking? Yes No
6. Do friends or relatives think you are a normal drinker? Yes No
7. Do you ever try to limit your drinking to certain times of the day or to certain places? Yes No
8. Are you always able to stop drinking when you want to? Yes No
9. Have you ever attended a meeting of Alcoholics Anonymous (AA)? Yes No
10. Have you gotten into fights when drinking? Yes No
11. Has drinking ever created problems with you and your spouse or girl/boyfriend? Yes No
12. Has your spouse (or other family member) ever gone to anyone for help about your drinking? Yes No
13. Have you ever lost friends or girl/boyfriends because of drinking? Yes No
14. Have you ever gotten into trouble at work or school because of drinking? Yes No
15. Have you ever lost a job because of drinking?  Yes  No

16. Have you ever neglected your obligations, your family, or your work for two or more days in a row because you were drinking?  Yes  No

17. Do you ever drink before noon?  Yes  No

18. Have you ever been told you have liver trouble? Cirrhosis?  Yes  No

19. Have you ever had delirium tremens (DTs), severe shaking, heard voices or seen things that weren’t there after heavy drinking?  Yes  No

20. Have you ever gone to anyone for help about your drinking?  Yes  No

21. Have you ever been hospitalized because of drinking?  Yes  No

22. Have you ever been a patient in a psychiatric hospital or on a psychiatric ward of a general hospital where drinking was part of the problem?  Yes  No

23. Have you ever been seen at a psychiatric or mental health clinic, or gone to a doctor, social worker, or clergyman for help with an emotional problem in which drinking had played a part?  Yes  No

24. Have you ever been arrested, even for a few hours, because of drunk behavior?  Yes  No

25. Have you ever been arrested for drunk driving or driving after drinking?  Yes  No
APPENDIX E

THINGS TO NOTE FOR DAY 2 EXPERIMENT
THINGS TO NOTE FOR DAY 2 EXPERIMENT

فرح Appointment Date/Time  ____________________________  _____:_____  

فرح (On weekends or evenings you will need to use the side door and someone will be  
waiting to let you in 5 minutes prior to the above scheduled time.)  

فرح Please note the following:  

• Eat a normal dinner the night before, without alcoholic drinks  
• No alcoholic drinks with dinner or following dinner  
• Limit the number of snacks after dinner  
• No food or drinks after midnight, only water  
• Skip breakfast the day of the appointment  
• A breathalyzer will be used to detect  
   alcohol. Also, we will be able to tell if you have eaten.  

فرح In addition, please note that you must inform Gina ahead of time if:  

• You need to take some form of medication  
• You cannot make the appointment on time  
• You experience any physical or mental fatigue prior to the scheduled  
   appointment time, i.e., you have a cold or are unusually fatigued.  

فرح Reminders:  

• You may want to bring homework or something to entertain yourself  
   for the waiting periods between sessions. A VCR is available if you want  
   to bring a movie.  
• We have snacks available, but, if you want, you may also bring your own  
   snacks or lunch.  

サー If you have any questions or comments concerning the experiment, please call Gina  
at the CAAR Human Factors Lab, phone number 226-7102.  

😊 Thank you for your participation!
APPENDIX F

POST QUESTIONNAIRE NO. 1

DRINKS CONSUMED AND FLIGHT PERFORMANCE
POST QUESTIONNAIRE NO. 1
DRINKS CONSUMED AND FLIGHT PERFORMANCE

DAY 2

In terms of the number of drinks (of whatever you drink most frequently), how much alcohol do you think you had today?

# of drinks ________

Did you feel any physical effects of whatever you had to drink?

__________ Yes  __________ No

If yes, what were they?

________________________________________________________________________

SESSION 2 (After the drinks)

Please circle the appropriate mark on each pair of scales below to represent your flight after the drinks as compared to the previous times you have flown the simulator.

1. Ability to Hold Altitude

| much worse | somewhat worse | same | somewhat better | much better |

Effort Required to Hold Altitude

| much less | somewhat less | same | somewhat more | much more |
2. **Sense of Movement**

<table>
<thead>
<tr>
<th></th>
<th>much worse</th>
<th>somewhat worse</th>
<th>same</th>
<th>somewhat better</th>
<th>much better</th>
</tr>
</thead>
</table>

**Effort Required to Sense Movement**

<table>
<thead>
<tr>
<th></th>
<th>much less</th>
<th>somewhat less</th>
<th>same</th>
<th>somewhat more</th>
<th>much more</th>
</tr>
</thead>
</table>

Please make any other comments about this flight as compared to previous flights. (Use back of sheet if you need more space.)
APPENDIX G
POST QUESTIONNAIRE NO. 2
DISCOMFORT LEVEL
## DIAGNOSTIC LEVEL

### POST QUESTIONNAIRE #2 (Circle the appropriate response)

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<th>2</th>
<th>3</th>
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<th>5</th>
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<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Nausea</td>
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<td>2</td>
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<td>5</td>
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<tr>
<td>Drowsiness</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Dizziness</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>Sweating</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Headache</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
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### SESSION TWO

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<td>3</td>
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<td>5</td>
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<tr>
<td>Increased Salivation</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Dizziness</td>
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<tr>
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<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Headache</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Dizziness</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Sweating</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0</td>
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<td>3</td>
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</table>
APPENDIX H

THRESHOLD VALUES FOR ALCOHOL PARTICIPANTS
Table 4

Alcohol Threshold Values

<table>
<thead>
<tr>
<th>Alcohol Participants</th>
<th>Session 1 (Prealcohol)</th>
<th>Session 2 (BAC)</th>
<th>Session 3 (Post alcohol)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Average</td>
</tr>
<tr>
<td>Participant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.0476</td>
<td>0.6282</td>
<td>0.8379</td>
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<tr>
<td>2</td>
<td>0.2716</td>
<td>0.2607</td>
<td>0.2661</td>
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<tr>
<td>3</td>
<td>0.6855</td>
<td>0.4946</td>
<td>0.5900</td>
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<tr>
<td>4</td>
<td>0.4171</td>
<td>0.3208</td>
<td>0.3690</td>
</tr>
<tr>
<td>5</td>
<td>0.2037</td>
<td>0.1838</td>
<td>0.1937</td>
</tr>
<tr>
<td>6</td>
<td>0.8730</td>
<td>0.9490</td>
<td>0.9110</td>
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<tr>
<td>Average</td>
<td>0.5831</td>
<td>0.4729</td>
<td>0.5280</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alcohol Participants</th>
<th>Session 4 (Post alcohol +1hr)</th>
<th>Session 5 (Post alcohol +2 hrs)</th>
<th>Session 6 (Post alcohol +3 hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Average</td>
</tr>
<tr>
<td>Participant</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>0.4311</td>
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<td>0.4612</td>
<td>0.4537</td>
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<td>5</td>
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<td>0.1838</td>
<td>0.2956</td>
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<tr>
<td>6</td>
<td>0.8536</td>
<td>0.9223</td>
<td>0.8880</td>
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<tr>
<td>Average</td>
<td>0.6283</td>
<td>0.4734</td>
<td>0.5509</td>
</tr>
</tbody>
</table>

Notes. All digits denote threshold values measured in degrees per sec$^2$. "Left" denotes deceleration threshold value. "Right" denotes acceleration threshold value. "Session 1" denotes prealcohol/placebo session. "Session 2" denotes BAC alcohol/placebo session. "Session 3" denotes post alcohol/placebo session at BAC = 0. "Sessions 4, 5, and 6" denote post alcohol/placebo sessions +1 hour, +2 hours, and +3 hours, respectively.
APPENDIX I

THRESHOLD VALUES FOR PLACEBO PARTICIPANTS
Table 5

Placebo Threshold Values

| Placebo Participants | Session 1 (Prealcohol) | | Session 2 (BAC) | | Session 3 (Post alcohol) | | Session 4 (Post alcohol +1hr) | | Session 5 (Post alcohol +2 hrs) | | Session 6 (Post alcohol +3 hrs) |
|----------------------|------------------------|---|----------------|---|-------------------------|---|-------------------|---|--------------------|---|
|                      | Left       | Right | Average | Left       | Right | Average | Left       | Right | Average | Left       | Right | Average | Left       | Right | Average | Left       | Right | Average | Left       | Right | Average | Left       | Right | Average |
| Participant          |            |       |         |            |       |         |            |       |         |            |       |         |            |       |         |            |       |         |            |       |         |            |       |         |
| 1                    | 1.0670     | 0.7485| 0.9078  | 1.1769     | 0.6149| 0.8959  | 1.1769     | 0.6149| 0.8959  | 1.0282     | 0.5881| 0.8082  | 1.0476     | 0.5614| 0.8045  | 1.0864     | 0.5347| 0.8105  |
| 2                    | 0.4688     | 0.4411| 0.4550  | 0.4624     | 0.4612| 0.4618  | 0.4785     | 0.4612| 0.4698  | 0.4462     | 0.4311| 0.4386  | 0.4268     | 0.4411| 0.4340  | 0.4268     | 0.4311| 0.4289  |
| 3                    | 0.3557     | 0.2473| 0.3015  | 0.3039     | 0.2473| 0.2756  | 0.3815     | 0.2473| 0.3144  | 0.3039     | 0.2206| 0.2622  | 0.3492     | 0.2423| 0.2957  | 0.3233     | 0.2206| 0.2719  |
| 4                    | 0.3492     | 0.2807| 0.3150  | 0.3815     | 0.2941| 0.3378  | 0.3686     | 0.3275| 0.3480  | 0.5044     | 0.3743| 0.4393  | 0.4915     | 0.5347| 0.5131  | 0.6984     | 0.5881| 0.6433  |
| 5                    | 0.5561     | 0.4110| 0.4836  | 0.5820     | 0.4010| 0.4915  | 0.5691     | 0.4010| 0.4850  | 0.5691     | 0.4010| 0.4850  | 0.5691     | 0.4010| 0.4850  | 0.5691     | 0.4010| 0.4850  |
| 6                    | 0.1940     | 0.2874| 0.2407  | 0.1989     | 0.2807| 0.2398  | 0.1940     | 0.2673| 0.2307  | 0.1940     | 0.2673| 0.2307  | 0.1940     | 0.2673| 0.2307  | 0.1940     | 0.2673| 0.2307  |
| Average              | 0.4985     | 0.4027| 0.4506  | 0.5176     | 0.3832| 0.4504  | 0.5281     | 0.3865| 0.4573  | 0.5125     | 0.3726| 0.4425  | 0.5160     | 0.3999| 0.4589  | 0.5513     | 0.3994| 0.4639  |

Notes. All digits denote threshold values measured in degrees per sec². "Left" denotes deceleration threshold value. "Right" denotes acceleration threshold value. "Session 1" denotes prealcohol/placebo session. "Session 2" denotes BAC alcohol/placebo session. "Session 3" denotes post alcohol/placebo session at BAC = 0. "Sessions 4, 5, and 6" denote post alcohol/placebo sessions +1 hour, +2 hours, and +3 hours, respectively.
APPENDIX J

FALSE POSITIVES OF
ALCOHOL AND PLACEBO PARTICIPANTS
Table 9

**False Positives**

<table>
<thead>
<tr>
<th>Participants</th>
<th>Alcohol Participants</th>
<th>Placebo Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Session 1</td>
<td>Session 2</td>
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<table>
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<tr>
<th>Participants</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
<th>Session 5</th>
<th>Session 6</th>
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APPENDIX K

NUMBER OF DIGITS MISSED

BY ALCOHOL AND PLACEBO PARTICIPANTS
Table 13

*Number of Digits Missed*

<table>
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<tr>
<th>Participants</th>
<th>Alcohol Participants</th>
<th>Placebo Participants</th>
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APPENDIX L

POST QUESTIONNAIRE NO. 1

PARTICIPANTS’ PERCEIVED ALCOHOL AND PERFORMANCE
Table 14

Participants' Perceived Alcohol Level and Performance, Post-Questionnaire No. 1

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Alcohol Level*</th>
<th>Ability to Hold Altitude</th>
<th>Effort to Hold Altitude</th>
<th>Sense of Movement</th>
<th>Effort to Sense Movement</th>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Alcohol Level*</th>
<th>Ability to Hold Altitude</th>
<th>Effort to Hold Altitude</th>
<th>Sense of Movement</th>
<th>Effort to Sense Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>-1</td>
<td>1</td>
<td>-2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>3.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>5</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>2.0</td>
<td>0</td>
<td>1</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>2.00</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. Performance score ratings were scored as follows: -2 much worse, -1 somewhat worse, 0 same, +1 somewhat better, and +2 much better.
* Alcohol Level = number of drinks participant perceived to have consumed.
APPENDIX M

POST QUESTIONNAIRE NO. 2

DISCOMFORT LEVEL REPORTED BY ALCOHOL PARTICIPANTS
Table 15

Discomfort Level Reported by Alcohol Participants, Post-Questionnaire No. 2

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Session 1</th>
<th>Participants (P)</th>
<th>Total (weighted sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1 P2 P3 P4 P5 P6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaise</td>
<td>0 0 1 0 0 0</td>
<td></td>
<td>1 (1)</td>
</tr>
<tr>
<td>Nausea</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>1 0 1 0 3 0</td>
<td></td>
<td>3 (5)</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0 0 0 0 1 0</td>
<td></td>
<td>1 (1)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0 0 1 0 0 0</td>
<td></td>
<td>1 (1)</td>
</tr>
<tr>
<td>Sweating</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Headache</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1 (1) 0 (0) 3 (3) 0 (0) 2 (4) 0 (0)</td>
<td>6 (8)</td>
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</tr>
</tbody>
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<table>
<thead>
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<th>Symptom</th>
<th>Session 2</th>
<th>Participants (P)</th>
<th>Total (weighted sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1 P2 P3 P4 P5 P6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaise</td>
<td>0 0 1 0 0 0</td>
<td></td>
<td>1 (1)</td>
</tr>
<tr>
<td>Nausea</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>1 1 1 2 4 1</td>
<td></td>
<td>6 (10)</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0 0 1 0 2 0</td>
<td></td>
<td>2 (3)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0 0 1 1 0 1</td>
<td></td>
<td>3 (3)</td>
</tr>
<tr>
<td>Sweating</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>0 0 0 0 1 2</td>
<td></td>
<td>2 (3)</td>
</tr>
<tr>
<td>Headache</td>
<td>0 0 1 0 0 0</td>
<td></td>
<td>1 (1)</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1 (1) 1 (1) 5 (5) 2 (3) 3 (7) 3 (4)</td>
<td>15 (21)</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Session 3</th>
<th>Participants (P)</th>
<th>Total (weighted sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1 P2 P3 P4 P5 P6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaise</td>
<td>0 0 1 0 0 1</td>
<td></td>
<td>2 (2)</td>
</tr>
<tr>
<td>Nausea</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>1 1 1 3 3 2</td>
<td></td>
<td>6 (11)</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0 0 1 0 1 0</td>
<td></td>
<td>2 (2)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0 0 1 1 0 0</td>
<td></td>
<td>2 (2)</td>
</tr>
<tr>
<td>Sweating</td>
<td>0 0 0 0 0 1</td>
<td></td>
<td>1 (1)</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>0 0 0 0 0 0</td>
<td></td>
<td>0 (0)</td>
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<tr>
<td>Headache</td>
<td>0 0 2 0 0 0</td>
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<td>1 (2)</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0 0 0 0 0 2</td>
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<td>2 (3)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1 (1) 1 (1) 6 (7) 2 (4) 4 (6) 4 (6)</td>
<td>16 (23)</td>
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</tr>
</tbody>
</table>

*Note. *The discomfort scale values ranged from no (0) to severe (4) discomfort.
APPENDIX N

POST QUESTIONNAIRE NO. 2

DISCOMFORT LEVEL REPORTED BY PLACEBO PARTICIPANTS
Table 16

Discomfort Level Reported by Placebo Participants, Post-Questionnaire No. 2

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Participants (P)</th>
<th>Total (weighted sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
<td>P2</td>
</tr>
<tr>
<td>Malaise</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sweating</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Headache</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1 (1)</td>
<td>0 (0)</td>
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</tbody>
</table>

Session 2

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Participants (P)</th>
<th>Total (weighted sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
<td>P2</td>
</tr>
<tr>
<td>Malaise</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sweating</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Headache</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1 (2)</td>
<td>0 (0)</td>
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</tbody>
</table>

Session 3

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Participants (P)</th>
<th>Total (weighted sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
<td>P2</td>
</tr>
<tr>
<td>Malaise</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Salivation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sweating</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Warmth</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Headache</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Epigastric Discomfort</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0 (0)</td>
<td>1 (2)</td>
</tr>
</tbody>
</table>

Note. *The discomfort scale values ranged from no (0) to severe (4) discomfort.