Risk-Taking Behavior: Effects of Ethanol, Caffeine, and Basal Sleepiness

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Study Objectives: This study examined the effects of ethanol, caffeine, and basal sleepiness on a laboratory measure of risk-taking behavior, the Stop Light Task. The aims were to determine whether sleepiness and ethanol degrade psychomotor speed and risky choice and whether caffeine attenuates these effects.

Design: Mixed design with participants chosen for basal level of sleepiness and each assessed under 4 conditions presented in a Latin-square crossover design.

Participants: Thirteen healthy adult volunteers aged 21 to 35 years.

Interventions: Participants received ethanol 0.5 g/kg and caffeine placebo, ethanol 0.5 g/kg and caffeine 150 mg, ethanol 0.5 g/kg and caffeine 300 mg, or a dual (ethanol-caffeine) placebo between 9:00 am and 9:30 am.

Measurements: The Multiple Sleep Latency Test (MSLT) was used to determine basal level of sleepiness. Subjects completed the Stop Light Task about 60 to 90 minutes after drug administration to assess psychomotor speed and risky choices.

Results: Seven subjects were classified as Alert (MSLT = 12.6 ± 2.0 minutes) and 6 Sleepy (MSLT = 8.1 ± 1.0 minutes). Sleepy compared to Alert subjects did not differ in psychomotor speed overall. Ethanol significantly slowed psychomotor speed relative to placebo, and ethanol-caffeine combinations attenuated this effect. Consistent with previous studies using the Stop Light Task, higher response requirements (FR15-FR50) and higher point loss probability (12.5%, 37.5%, 100%) significantly decreased risky choice, across sleepiness and treatment conditions. Alert subjects made “go” (primary measure of risk-taking) choices more often at lower response requirements and less often at higher response requirements, relative to Sleepy subjects. Ethanol did not significantly affect “go” choices but did produce changes in “go” choices as a function of response requirement. Given their more optimal pattern of choice behavior, Alert subjects gained significantly more money than Sleepy subjects; ethanol and caffeine combinations did not significantly affect money earned.

Conclusions: These data suggest that sleepiness moderates risky choice such that Alert subjects have improved choice “acuity.” Also, under conditions where risk-taking depends on responding rapidly (like the Stop Light Task), ethanol may also impair responding and caffeine may attenuate this effect.

Key Words: Ethanol, Caffeine, Sleepiness, MSLT, Risk-taking behavior

Introduction

The sedative and performance-disruptive effects of both ethanol and sleepiness, as well as their interaction, have been well documented scientifically. In general, these studies have focused on simple motor, attention, and memory processes. The effect of ethanol on more complex decision-making processes has received some research attention, particularly in regard to assessing and taking risks. We define risk taking as decision-making or choice behavior that has a given, but uncertain, ratio of gain (ie, reinforcement) to loss (ie, punishment) as its consequence. Whether ethanol increases risk taking remains controversial; the data are equivocal. Whereas ethanol and risk-taking effects have been studied, the impact of sleepiness on risk taking, either as a trait variable or as a state variable (eg, drug effect), has received limited systematic investigation. In one of the few studies of risk taking during sleep deprivation, participants were required to choose cards blindly from 4 packs. The cards carried rewards, and some penalties, with the 4 packs differentially stacked with reward versus penalty cards. Non-sleep-deprived participants quickly learned to maximize their earnings and avoid packs with a no-win value. However, the sleep-deprived participants continued to choose from high-risk packs, despite their heavy losses. Given that our previous studies have shown that sleepiness exacerbates ethanol impairment of simple motor and attention behavior, it would be important to know whether risk-taking behavior is similarly affected. We are aware of no studies of the interactive effects of ethanol and sleepiness on risk taking.

Finally, much research has focused on various countermeasures to the impairing effects of ethanol and sleepiness. Caffeine has been shown in several studies to reverse the sedative and performance-disruptive effects of sleepiness. For example, 75 and 150 mg caffeine increased alertness after 1 night of sleep loss. Similarly, caffeine has been shown in some studies to reverse the sedative and performance-disruptive effects of small ethanol doses. However, although caffeine reversed the performance-disruptive effects of ethanol, it did not alter the subjective experience of intoxication. The potential of caffeine to reverse any ethanol, sleepiness, or combined ethanol-sleepiness effects on risk taking would be of interest.

The present paper, part of a larger study, reports on the effects of basal sleepiness and ethanol on risk-taking behavior. We used a recently developed laboratory model of risk-taking choice behavior, the Stop Light Task. The first aim of this study was to determine the effects of basal sleepiness (Multiple Sleep Latency Test [MSLT]: average daily sleep latency), ethanol (0.5 g/kg) and caffeine (0, 150, or 300 mg) on psychomotor speed, independent of choice contingencies. Thus, we evaluated whether subjects classified as Sleepy (MSLT < 10 minutes) relative to Alert...
(MSLT > 10 minutes), and ethanol relative to placebo, modulated response rates during the baseline period of the Stop Light Task. We predicted that ethanol, particularly in sleepy subjects, would slow response rate and that caffeine would attenuate this effect. The second aim was to determine whether ethanol, or its interaction with basal sleepiness, modulated risk taking (proportion of “go” choices). We foresaw 2 alternative outcomes. First, the psychomotor slowing predicted to occur with ethanol and/or basal sleepiness might precipitate a generalized decrease in risk taking. Second, ethanol and/or moderate sleepiness might lead to selective changes in risk taking when conditions are not optimal, eg, when the task response requirement or probability of losing money is high. We predicted that caffeine would attenuate the effects of basal sleepiness or ethanol on risk-taking choices.

**METHODS**

**Participants**

Participants were 13 adults from ages 21 to 35 years in good physical and psychological health, as determined by an extensive screening. A physical examination and a structured psychiatric interview (Structured Clinical Interview for DSM-IV Axis I Disorders) were given; the Cornell Medical Index was completed; and drug-use (including ethanol quantity and frequency, caffeine, and over-the-counter medications) and medical and psychiatric histories were taken. Standard laboratory analyses of blood and urine samples were obtained, which included a urine drug screen. Volunteers who reported smoking more than 10 cigarettes per day and consuming more than 150 mg caffeine per day and more than 14 standard alcohol drinks per week were excluded. Volunteers with a history of drug or alcohol abuse or dependence; any existing medical or psychiatric disease; current drug or alcohol abuse or dependence; a positive urine drug screen for a history of drug or alcohol abuse or dependence; a positive urine drug screen for amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine metabolites, opiates, phencyclidine, methadone, and propoxyphene; or reporting use of any central nervous system-acting drugs were excluded. This study was reviewed and approved by the Human Rights Board of the institutions. All participants signed a written, informed consent and received payment for their participation.

Following the initial screening described above, each participant underwent additional evaluation to validate normal nocturnal sleep and level of daytime sleepiness and alertness. The evaluation included a sleep history, a nocturnal sleep recording, and a MSLT. As part of the sleep history, each participant completed a 2-week sleep diary of usual sleep habits and a detailed questionnaire regarding sleep-wake complaints. Those with irregular sleep-wake schedules reported on their logs, defined as bedtimes or times of arising varying by more than 2 hours, bedtimes later than midnight, or any evidence suggestive of a circadian rhythm disorder were excluded.

On the screening sleep-laboratory night, participants reported 1 hour before the 11:00 PM bedtime. Electrodes were attached for a standard sleep recording, and participants went to bed at 11:00 PM to remain in bed for 8 hours. All sleep recordings were scored in 30-second epochs according to the standards of Rechtschaffen and Kales. Participants were required to have a sleep efficiency (percentage of sleep time per 8 hours of time in bed) of 85% or greater and periodic leg movement or respiratory disturbance indexes less than 10. The following day, each participant underwent a screening MSLT as described below.

**Study Design**

The study used a mixed design with 1 between-subject factor, basal level of sleepiness-alertness (as described below), and a within-subject factor, the 4 ethanol-caffeine treatments. Participants received each of the 4 treatments under double-blind conditions, presented in a Latin square design, and on each of 4 days separated by 3 to 7 recovery days. The treatments were ethanol placebo plus caffeine placebo, ethanol 0.5 g/kg plus caffeine placebo (EC000), ethanol 0.5 g/kg plus caffeine 150 mg (EC150), and ethanol 0.5 g/kg plus caffeine 300 mg (EC300). Additional within-subject factors specific to the Stop Light Task are described below.

**Experimental Procedures**

The night before each experimental day, participants reported to the sleep laboratory at 10:00 PM and went to bed from 11:00 PM to 7:00 AM. Sleep was monitored by actigraphy to ensure adequate sleep time (ie, > 6.7 hours) over the 8-hour time in bed. No experimental session had to be rescheduled due to inadequate sleep the previous night. From 7:30 AM to 8:00 AM, a small breakfast was provided. Lunch was served at 1:00 PM. Caffeine-containing beverages were not allowed during the entire time the subject attended the laboratory. Participants were monitored on laboratory days to ensure they did not nap, take drugs (licit or illicit), or alcohol. None of the subjects smoked cigarettes; therefore, smoking restrictions were not needed. Participants were allowed to maintain their regular exercise habits during the free periods throughout the day and during the unscheduled evening hours before bedtime. During these free periods, they also were allowed to watch television and read.

**Ethanol-Caffeine Administration**

Caffeine (000, 150, and 300 mg) was prepared by the hospital research pharmacy in opaque capsules and administered at 8:55 AM. Ethanol (0.5 g/kg) or ethanol placebo was consumed from 9:00 AM to 9:30 AM. Ethanol was prepared in a 1:4 ratio with 80-proof vodka added to chilled tonic water, and the placebo consisted of the chilled tonic water (in equal volume to the ethanol) with 3 drops of ethanol floated on the surface for gustatory and olfactory cues. The total ethanol or placebo beverage was administered in 3 separate cups every 10 minutes to ensure evenly spaced consumption over the 30-minute period. Breath ethanol concentration (BrEC) was measured just before each latency test of the MSLT.

**Multiple Sleep Latency Test**

The MSLT was conducted at 10:00 AM, noon, 2:00 PM, and 4:00 PM according to the standard protocol. During each sleep-latency test, participants laid down in a bed in quiet and dark rooms with the instruction to go to sleep. On the screening day testing, participants remained in bed for 20 minutes after sleep onset as defined below, or for 20 minutes if sleep onset did not occur (to test for sleep-onset rapid eye movement [REM] periods). On experimental days, participants remained in bed until 3
consecutive epochs of Stage 1 sleep, an epoch of another sleep stage, or 20 minutes of wake occurred. Experienced scorers, who were unaware of subject group classification and treatment condition, scored sleep latency as minutes to the first epoch (30 seconds) of sleep. Time (minutes) to sleep onset for each test was averaged over the 4 tests on each day. To qualify for the study, participants had an average daily sleep latency of 5 to 15 minutes and no sleep-onset REM periods on the screening MSLT.

Stop Light Task

The Stop Light Task required participants to respond to a computerized “traffic signal” displayed on a video monitor and make decisions that result in actual money loss or gain. The green light signaled the participant to begin responding on the computer keyboard during each of 48 discrete trials of a session. The “traffic light” had a point counter above it and a response counter below it. Typing 100 x-y key combinations before the red light appears earned points (fixed ratio [FR] 100) that were translated to monetary value. When the yellow light replaced the green, following varying numbers of responses toward completing the FR100, the participant decided whether to attempt completion of the remaining sequence. To advance the computer program, the subject was told that it is necessary to respond during the green light but that there is no consequence to responding faster or slower during the green light, ie, choices are only made once the yellow light appears. Onset of the yellow light occurred when 50, 45, 40, 35, 30, 25, 20, or 15 x-y responses remain on the FR100; this residual FR factor—called Response Requirement—varied randomly across trials. Duration of the yellow light on a given trial was 1, 3, 5, 7, or 9 seconds (mean = 5 seconds) and varied randomly across trials. A counterbalancing scheme was used so that short and long yellow-light durations were paired equally often with shorter and longer response requirements. In separate trial blocks of the task (organized in 6 blocks of 8 trials), participants were signaled that the probability of point loss was 12.5%, 37.5%, or 100% (each probability of point loss was presented in 2 blocks of trials) if they failed to complete the FR100. On each trial, there were 3 possible outcomes: Participants could have stopped responding during the yellow light and conserve their current earnings; they could have chosen to continue (ie, take a risk) and complete the FR100 before the red light and thereby earn 25 points (+25¢); or they could have continued and failed to complete the FR100 before the red light, with the possibility of losing 25 points (-25¢) depending on the probability of point-loss condition. Participants were given a “spot” amount (ie, cash advance) of 200 points, or $2.00, at the start of the task and could earn approximately $8 each session. The dependent measures generated in this task were rates of responding during the green-light and yellow-light periods, percentage attempts to complete the FR100 (ie, risk taking), and points obtained (ie, money earned).

Data Analysis

The primary dependent measure of risk taking was the proportion of “go” choices (completed and failed attempts, regardless of points/monetary outcome) in each experimental condition. Secondary measures were rates of responding during the green light (ie, decreases reflect psychomotor slowing) and yellow light (which generally correspond to the proportion of “go” choices), and points earned. Analysis of each measure used a model analysis of variance. In all analyses, MSLT group (Sleepy and Alert) was the between-subject factor; Treatment Condition (4 levels: EC000, EC150, EC300, and Placebo), Point Loss Probability (PLP; 3 levels: 12.5%, 37.5%, and 100%) and Response Requirement (8 levels: FR15 to FR50) were the within-subject factors. For the Condition factor, we tested a linear contrast (EC000, EC150, EC300, Placebo) based on the assumptions that ethanol would influence performance relative to placebo, and that caffeine would dose-dependently reverse ethanol-related performance effects (either on psychomotor slowing or risk taking). In all analyses, Huynh-Feldt-corrected probability levels were used as appropriate to correct for sphericity of repeated measures.

RESULTS

Participant Characteristics

Average daily sleep latency of all participants varied on the screening MSLT from 6.5 to 14.9 minutes. Using a cutpoint of 10 minutes, which is the average basal MSLT value in a large sample of young healthy adults, 17 participants (4 men and 3 women) were classified as Alert and 6 participants (2 men and 4 women) as Sleepy. The mean (± SD) daily screening sleep latency of the Sleepy group was 8.1 ± 1.0 minutes (range, 6.5 to 9.5 minutes) and that of the Alert group was 12.6 ± 2.0 minutes (range, 10.0 to 14.9 minutes), t = 5.10, P < .001. Compared to a large sample of healthy young adults, mean daily sleep latency of the Sleepy group is at the 38th percentile and that of the Alert group is at the 62nd percentile. (Although these group differences indicate that subjects were moderately sleepy and moderately alert, this modifier has been omitted for simplicity.) The groups did not significantly differ on any demographic factors.

Ethanol Concentration

Mean BrEC (± SD) was 0.043% ± 0.020% at 9:55 AM, declined to 0.024% ± 0.014% at 11:55 AM, and reached 2 at 1:55 PM. The Stop Light Task began at 10:30 AM and ended at about 11:00 AM; therefore, by extrapolation, BrEC would have been about 0.038% at task initiation and about 0.033% at task completion, given that ethanol metabolism is linear. BrEC did not differ between the 3 caffeine treatments or the 2 basal sleepiness groups.

Stop Light Task Performance

Psychomotor Speed

As shown in Table 1, average green-light rates of responding (across treatment conditions) tended to be slower for Sleepy than Alert subjects, but this was not statistically significant, Group F1,11 = 3.50, P < .09. Green-light response rates did not differ significantly between conditions in the omnibus analysis, F3,33 = 2.00, P = .14. However, the linear contrast across conditions (EC000 < EC150 < EC300 < PBO) showed that ethanol alone produced slower responding than placebo and that the ethanol-caffeine combinations produced intermediate response rates, F1,11 = 7.37, P < .02. The interaction of basal sleepiness and treatment condition was not significant, F3,33 = 1.89, P = .16.
Risk Taking

Table 2 presents the proportion of “go” choices for the basal sleepiness groups and treatment conditions. These data suggest that, in the placebo condition, Sleepy subjects made fewer risky choices (.66) than Alert subjects (.52). However, the Group × Condition interaction was not significant, F(3,33) = 2.16, P = .14, nor were the individual main effects of these factors.

As routinely occurs with the Stop Light Task, greater response requirements decreased the proportion of “go” choices, F(7,77) = 27.94, P < .0001; the linear contrast was significant, F(1,11) = 57.19, P < .0001 (see Figure 1, left panel). Also as generally occurs with this task, higher point-loss probability decreased the proportion of “go” choices (.64 ± .09, .57 ± .08 and .46 ± .09, in the 12.5%, 37.5%, and 100% probability of point-loss conditions, respectively), F(2,22) = 9.13, P < .002; the linear contrast was significant, F(1,11) = 11.00, P < .01 (see Figure 1, right panel). In addition, the proportion of “go” choices decreased with the combination of higher probability of point loss and greater response requirements, F(14,462) = 1.93, P < .05.

Figure 1 (left panel) shows that Alert subjects more frequently made “go” choices at lower response requirements (FR20–FR30, which are more favorable for earning points) and less frequently made “go” choices at higher response requirements (FR40–FR50, which are less favorable for earning points), relative to Sleepy subjects; this interaction of group and response requirement was confirmed statistically, F(7,77) = 3.10, P < .05. Alert compared to Sleepy subjects tended to “go” more often when point loss was unlikely but tended to “go” less often when point-loss probability was certain (see Figure 1, right panel); however, this apparent Group × probability of point loss interaction was not confirmed statistically, F(2,22) = 2.05, P = .16.

Rates of yellow-light responding (Table 3) were significantly affected by the interaction of treatment condition and basal

| Table 1—Effects of Condition and Basal Sleepiness on Psychomotor Speed |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| Group | Ethanol/Caffeine Condition | EC000 (SEM) | EC150 (SEM) | EC300 (SEM) | Placebo (SEM) |
| Sleepy | 4.08 (.18) | 4.08 (.30) | 4.13 (.24) | 4.43 (.28) | 4.18 (.83) |
| Alert | 4.50 (.17) | 4.92 (.28) | 4.86 (.22) | 4.75 (.26) | 4.76 (.60) |
| Marginal | 4.29 (.12) | 4.50 (.20) | 4.50 (.16) | 4.59 (.19) | 4.47 (.15) |

Data are presented as mean (SEM) responses per second during green-light period.
EC000 refers to ethanol plus placebo caffeine condition; EC150, ethanol plus 150 mg caffeine; EC300, ethanol plus 300 mg caffeine.

| Table 2—Effects of Condition and Basal Sleepiness on Risk Taking |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| Group | Ethanol/Caffeine Condition | EC000 (SEM) | EC150 (SEM) | EC300 (SEM) | Placebo (SEM) |
| Sleepy | .53 (.13) | .51 (.13) | .52 (.12) | .66 (.11) | .56 (.12) |
| Alert | .58 (.12) | .55 (.12) | .57 (.12) | .52 (.10) | .56 (.11) |
| Marginal | .55 (.09) | .53 (.09) | .55 (.08) | .59 (.08) | .56 (.08) |

Data are presented as mean (SEM) proportion of ‘go’ choices during yellow-light period.
EC000 refers to ethanol plus placebo caffeine condition; EC150, ethanol plus 150 mg caffeine; EC300, ethanol plus 300 mg caffeine.

Figure 1—Effects of Basal Sleepiness group (Alert, n = 7; Sleepy, n = 6) and Response Requirement (left panel) or Point Loss Probability (right panel) on mean (SEM) proportion of “go” choices. Alert subjects increased their “go” choice rate under conditions that were more favorable for earning money (ie, at low response requirements, FR20–FR30; and low point-loss probability, 12.5%), and decreased their “go” choice rate under conditions that were less favorable for earning money (ie, at high-response requirements, FR40–FR50; and high point-loss probability, 100%), relative to Sleepy subjects. Thus, the choice behavior pattern of Alert subjects was less risky than that of Sleepy subjects. See text for details. FR refers to fixed ratio.
sleepiness, $F_{3,33} = 4.18, P < .02$, consistent with the pattern of “go” choices. Alert subjects responded most slowly following placebo, and their mean response rates increased slightly (by about 0.4 responses per second) for all ethanol conditions. Conversely, Sleepy subjects responded most rapidly under placebo conditions, and their mean response rates decreased somewhat (by about 0.8 responses per second) for all ethanol conditions. Neither Group nor Condition independently affected rates of yellow-light responding.

When the odds of point loss were low (12.5%), Alert subjects tended to respond more rapidly during the yellow light than Sleepy subjects; however, this impression was not statistically supported, $Group \times probability$ of point loss, $F_{2,22} = 2.89, P < .08$. Similar to the pattern observed for “go” choices, rates of yellow-light responding decreased as probability of point loss increased, $F_{2,22} = 7.88, P < .003$, as response requirement increased, $F_{7,77} = 22.79, P < .0001$, and with the interaction of these 2 factors, $F_{14,462} = 2.53, P < .02$.

Based on their more optimal pattern of choices, ie, more “go” choices under more favorable conditions of low probability of point loss and response requirement and fewer “go” choices under less favorable conditions of high probability of point loss and response requirement, Alert subjects gained significantly more money than Sleepy subjects across conditions, $F_{1,11} = 6.67, P < .03$ (see Table 4). Ethanol plus caffeine combinations did not significantly alter the amount of money (points) earned during task performance, Condition $F_{3,33} < 1, P = .76$. The apparent tendency for Sleepy subjects to earn the least money under ethanol compared to placebo conditions was not significant, Group $\times$ Condition $F_{1,32} = 1.43, P = .25$. As expected, amount of money earned decreased as probability of point loss increased, $F_{2,22} = 12.91, P < .0001$, and response requirement increased, $F_{7,77} = 32.18, P < .0001$, but the interaction of these 2 factors was not significant.

DISCUSSION

This study showed that monetary risk-taking behavior is modulated by individual differences in basal sleepiness, in conjunction with response requirements. Response requirement and probability of money loss are variables that routinely influence risk taking[10,16,20-22] and in animal models of risky choice behavior.[23,24] In the present study, Alert subjects increased their “go” choice rate under conditions that were more favorable for earning money (ie, low response requirements) and decreased their “go” choice rate under conditions that were less favorable for earning money (ie, high response requirements), relative to Sleepy subjects. Stated another way, Alert subjects were more sensitive to task contingencies, ie, the slopes of their response requirement and point-loss probability functions were steeper than for Sleepy subjects (see Figure 1). The result of this choice pattern was that Alert subjects earned significantly more money than Sleepy subjects overall (see Table 4). In this regard, the choice behavior of Alert subjects was less risky and more optimal compared to Sleepy subjects. This finding closely resembles results of a previous study that compared the card choices of sleep-deprived and non–sleep-deprived subjects.[12] Taken together, these findings suggest that sleepiness degrades an individual’s “acuity” to make complex decisions.

A critical point concerns the nature of the putative individual difference that has been identified, ie, basal state of sleepiness. When tested with an objective measure of daytime sleepiness (the MSLT) after 8 hours of time in bed the previous night, healthy normal people with no nocturnal sleep or complaints of daytime sleepiness and a normal nocturnal sleep recording the previous night vary in their mean daily sleep latency from 2 to 20 minutes, which are the lower and upper limits of the test.[19] The known determinants of daytime sleepiness are primary sleep disorders (ie, narcolepsy, sleep apnea, or periodic leg movement disorder), effects of drugs (ie, initiation or discontinuation), and acute or chronic reduction of bedtime.[25] Primary sleep disorders, drug use, and acute bedtime reduction were all ruled out in this study.

While all participants in the present study reported habitual and stable bedtimes of more than 6.5 hours, we infer that the bedtime of the Sleepy subjects is insufficient relative to their biologic sleep need. Others have argued that short sleep latencies on the MSLT, in the absence of other known causes of sleepiness, may merely reflect differences in the ability to fall asleep rapidly. We infer that the sleepiness of the Sleepy subjects in this study is probably due to insufficient sleep, based on previous studies with similar screening procedures showing that increased bedtimes of 10 or 12 hours nightly for 1 to 4 weeks in such sleepy people leads to an increase in their alertness.[26-28] This study did not include such a sleep extension, and so the cause of the sleepiness of the present study participants cannot be definitively established.

A number of factors may contribute to an individual’s habitual sleep insufficiency, none of which has been extensively investigated. Individuals may be insensitive to their sleepiness, particularly when the sleepiness is chronic. Recall that the participants of this study did not report problems with daytime sleepiness. Other studies have shown that individuals with even more extreme levels of daytime sleepiness fail to recognize their exces-

Table 3—Effects of Condition and Basal Sleepiness on Risk Taking

<table>
<thead>
<tr>
<th>Group</th>
<th>Ethanol/Caffeine Condition</th>
<th>Marginal</th>
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<tbody>
<tr>
<td></td>
<td>EC000</td>
<td>EC150</td>
</tr>
<tr>
<td>Sleepy</td>
<td>2.76 (.52)</td>
<td>2.61 (.48)</td>
</tr>
<tr>
<td>Alert</td>
<td>3.20 (.49)</td>
<td>3.37 (.44)</td>
</tr>
<tr>
<td>Marginal</td>
<td>2.98 (.36)</td>
<td>2.99 (.33)</td>
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</table>

Data are presented as mean (SEM) responses per second during yellow-light period.

Table 4—Effects of Condition and Basal Sleepiness on Risk-Taking

<table>
<thead>
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<th>Group</th>
<th>Ethanol/Caffeine Condition</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EC000</td>
<td>EC150</td>
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<tr>
<td>Sleepy</td>
<td>2.78 (2.06)</td>
<td>1.39 (1.85)</td>
</tr>
<tr>
<td>Alert</td>
<td>6.10 (1.91)</td>
<td>9.52 (1.71)</td>
</tr>
<tr>
<td>Marginal</td>
<td>4.44 (1.40)</td>
<td>5.46 (1.26)</td>
</tr>
</tbody>
</table>

Data are presented as mean (SEM) dollars earned.

EC000 refers to ethanol plus placebo caffeine condition; EC150, ethanol plus 150 mg caffeine; EC300, ethanol plus 300 mg caffeine.
sive sleepiness. Other individuals recognize their sleepiness but, due to social and economic demands, are unable to establish sufficient and regular bedtimes, and they try to cope. Finally, others may recognize their sleepiness and insufficient sleep time, choose such a life style, and ignore the risks associated with such sleepiness. One question for future research is whether such moderately sleepy subjects are risk-taking individuals in general (eg, they take risks with their sleep habits, leading to further impairments in decision-making ability).

Alternatively, such chronically sleepy individuals may be otherwise normal, but their sleep deficiency increases their vulnerability to making poor choices in situations where tangible losses can occur. Individuals with daytime sleepiness associated with a variety of causes have increased rates of automobile accidents. It has always been assumed that the automobile accidents of sleepy people can be attributed to their falling asleep at the wheel. The present study results raise a question as to the extent to which risk taking may contribute to the higher accident rate of sleepy individuals. Specifically, the risk-taking “acuity” of these sleepy subjects was degraded.

The effects of ethanol on choice behavior in the present study were generally smaller than those of basal sleepiness. This could be due, in part, to the moderate ethanol dose (0.5 g/kg) that was administered, which produced BrEC of 0.03% to 0.04% (1 hour after ethanol ingestion; descending limb of time-response curve) when subjects performed the Stop Light Task. Ethanol did slow psychomotor speed relative to placebo, and caffeine attenuated this effect; however, ethanol administration did not significantly influence risky choice. A higher ethanol dose might have produced greater effects on risky choice but would also have made it more difficult to demonstrate caffeine reversal of ethanol effects. It has been noted previously that BrECs below 0.05% do not consistently impair behavior in most individuals. One previous study showed that a wide range of BrECs (up to 0.15%) was not associated with changes in risk-taking behavior using a computer task with a variable schedule of point loss, which is not unlike the point-loss probability manipulation in the present experiment. Another explanation for the weak impact of ethanol on risky choice in this study may be the nature of the task. For instance, a recent preliminary report using a novel choice task that does not depend on speed of responding found ethanol dose-dependent (0.2, 0.4, and 0.8 g/kg) increases in risk taking.

Relative to placebo, ethanol increased yellow-light rates of responding for Alert subjects but decreased rates of responding for Sleepy subjects; this produced a significant interaction (see Table 3). This pattern was similar to a (nonsignificant) trend for “go” choices and is consistent with the idea that ethanol produced rate-dependent effects. That is, when baseline (placebo) response rates are high, ethanol decreases response rate, whereas when baseline response rates are low, ethanol increases response rate.

In summary, basal sleepiness moderated psychomotor speed and risk-taking behavior on the Stop Light Task. Risk taking within this procedure depends, in part, on speed of responding (ie, to complete the response requirement) once the choice decision is made. Ethanol significantly slowed psychomotor speed relative to placebo, and ethanol-caffeine combinations produced intermediate response rates. Therefore, under these experimental conditions—and, perhaps, naturalistic conditions where speed of responding is integral to risk taking—moderate doses of ethanol may indirectly influence risky choice. This potential effect of ethanol, however, appears to depend on the baseline state of responding, which is a function of an individual’s alertness (which caffeine may enhance). In the present study, individuals who were sufficiently well rested showed a cognitive advantage, ie, their choices were better calibrated (compared to sleepy subjects) to the likely consequences of their actions. The use of real consequences (eg, money) in this task is probably an important determinant of the risky choices shown by these subjects. In future studies, it might be useful to vary the type and magnitude of consequence (eg, appetitive or aversive) to assess the influences of basal sleepiness and pharmacological variables.

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