Alcohol Effects on Movement-Related Potentials: A Measure of Impulsivity?*

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ABSTRACT. *Objective:* To assess the effects of acute alcohol intoxication on lateralized readiness potential (LRP), a central measure of movement-related brain activity, and the potential association of such effects with personality measures. *Method:* Male volunteers (N = 12) alternated responding hands during a "go/no go" verbal recognition task across all four sessions of the balanced placebo design in which beverage content (either juice only or a vodka and juice mixture that raised the average blood alcohol concentration to 0.045%) was crossed with instructions as to beverage content. *Results:* Whereas the instructions had no effect on behavioral (response accuracy and reaction time) and physiological (LRP) measures, alcohol decreased reaction times adjusted for psychometer speed. As expected, large LRPs were recorded on "go" trials and were not affected by the beverage. However, the "no go" words that did not require and did not evoke motor responses, also evoked significant LRPs under alcohol but not placebo. Since only trials with correct responses and correct abstentions from responses were included in the averages, the motor preparation was not completed and was terminated before the motor response on "no go" trials. Similarly, there was a decrease in spectral power of the movement-related mu-rhythm on "no go" trials under alcohol. *Conclusions:* Alcohol may result in disinhibition such that the "response execution" process is activated based on very preliminary stimulus evaluation. This alcohol-induced brain activity signaling premature motor preparation exhibited correlation trends with personality traits related to impulsivity, hyperactivity and antisocial tendencies, thus concurring with other evidence that indicates commonalities between alcoholism and impulsivity, disinhibition and antisocial behaviors. The LRP on "no go" trials could potentially be used as a psychological index of the impulsiveness induced by alcohol intoxication. (*J. Stud. Alcohol* **61:** 24-31, 2000)

A HIGH INCIDENCE of alcohol intoxication associated with violent crimes (Collins, 1981) is found in many countries (Murdoch et al., 1990) and has led to hypotheses about alcohol-induced aggression. Laboratory research on aggressive behavior indicates that inebriation indeed increases the likelihood of aggression (Bushman and Cooper, 1990) and that it interacts with the level of provocation (Gustafson, 1993), cognitive functions of the frontal lobes (Lau et al., 1995), dose (Chermack and Taylor, 1995) and gender (Giancola and Zeichner, 1995). However, the relationship between alcohol and aggression is not straightforward. Behavioral acts that may be labeled as aggressive are remarkably varied and include such aspects as impulsivity, disinhibition, social inappropriateness, impaired thought processes and lack of sexual restraint. In spite of correlational evidence linking alcohol and aggression to neurochemical changes in humans (Virkkunen and Linnoila, 1993), direct physiological evidence of alcohol effects on impulsivity as an aspect of aggression is missing. In a behavioral study, Parsons et al. (1972) reported that chronic alcoholics were unable to suppress fast responding in a task that required slow motor control, suggesting more hasty or impulsive motor behavior. A closer scrutiny of the effects of alcohol on the preparation for motor responses may elucidate the physiological basis of impulsive acts.

The lateralized readiness potential (LRP), a central measure of brain activity related to the preparation to move, may potentially serve as an index of impulsive motor behavior. In tasks requiring an overt response, LRP is a measure of the motor-planning aspect of the stimulus processing which occurs concurrently with stimulus perception, evaluation and integration. A negative scalp potential recorded contralaterally to the responding hand (Rohrbaugh et al., 1976) is thought to be a later part of the slow negative readiness potential (Bereitschaftspotential) that precedes voluntary movement (Deecke, 1987; Shibasaki, et al., 1980). It is primarily generated in precentral and premotor cortices as suggested by intracranial recordings (Halgren et al., 1994; Ikeda et al., 1992; Rektor et al., 1994). A measure of lateralization of this potential is obtained by subtracting the ERP recorded over motor/premotor cortex ipsilaterally to the responding hand from the ERP recorded contralaterally to the responding hand. Subsequently, the LRPs of both hands are averaged

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together (Coles, 1989). This procedure permits inspection of movement-related potentials since it eliminates other activity that is unrelated to motor response. Although the LRP has been utilized in many studies and considerable evidence exists on its evoking and modulating parameters, the effects of alcohol on the LRP have not previously been investigated.

In order to provide an assessment of the movement-related cortical activity in a manner complementary to the LRP, the EEG data were also submitted to the analysis of spectral power in frequency domain. Rhythmic oscillations around 10 to 20 Hz localized in the Rolandic cortex (mu-rhythm) are considered to indicate an "idling" state of the sensory-motor cortex and are transiently suppressed by motor planning and movements, predominantly contralateral to the movement (Chatrian, 1976) in a manner specific to the somatic cortical representation of the moving body part (Arroyo et al., 1993; Pfurtscheller et al., 1997). The same procedure used to derive the LRPs in the time domain was also applied in the frequency domain, resulting in the lateralized event-related spectral power (LERSP).

The purpose of this study was to determine the effects of moderately low level acute intoxication on the LRP (obtained in the time domain) and the LERSP (obtained in the frequency domain) as central indices of motor response preparation, as well as to assess their potential association with personality measures. The results reported here are a portion of a comprehensive study investigating effects of alcohol on physiological indices of higher cognitive functions. Detailed descriptions of other tasks will be reported elsewhere.

Method

Subjects

Twelve healthy, right-handed, nonsmoking men (mean [±SD] age = 23.5 ± 2.5 years) completed all four sessions of the experiment. They were all social drinkers, native speakers of English and reported no medical condition, illicit drug abuse or excessive drinking. The participants reported no alcohol abuse in their families.

Design

Each subject participated in all four sessions of a balanced placebo design obtained by crossing the factors of beverage and instructions as to the beverage content ("expectancy"): (1) given alcohol, told alcohol (GATA); (2) given alcohol, told juice (GATJ); (3) given juice, told alcohol (GJTA); (4) given juice, told juice (GJTJ). Except for the consumed beverage and information concerning the beverage content, the same protocol was followed in each recording session.

In order to minimize the potential effects of variability in alcohol metabolism and circadian rhythms, the recording sessions started between 3 and 4 pm and were scheduled at least 2 days apart. Subjects were asked to abstain from food for 3 hours and from alcohol for 24 hours prior to each experimental session. In addition to the verbal recognition task, the protocol included a simple tone discrimination task and a mood-rating questionnaire. The blood alcohol concentrations (BACs) were monitored throughout the experiment with an Alco-sensor III breath analyzer (Intoximeters, Inc., St. Louis, MO). On average, the verbal memory task was administered 72 minutes after the drink presentation, just after the participants reached a peak BAC (0.045%); the measures taken before and after the task showed BACs of 0.045% and 0.044%, respectively. At the end of each experimental session the subjects rated the task difficulty, the beverage content, self-perceived level and latency-to-maximum of intoxication. They remained in the laboratory until their BAC diminished to negligible (i.e., below 0.01%) levels.

Prior to the beginning of the study, the subjects were informed in writing that they would consume alcohol or a placebo and that the information given to them regarding the beverage content might be inaccurate. The written consent was approved by the appropriate institutional human subject protection committees. Upon completion of the experiment the participants were asked about their suspicions regarding deception. They were debriefed and the exact design and purpose of the study were explained in detail.

All subjects participated in an introductory recording session prior to the first experimental session. During this session they were familiarized with the laboratory setting and with the recording procedure. In addition, they filled out the following questionnaires: Michigan Alcoholism Screening Test (MAST; Selzer, 1971); Alcohol Use Questionnaire (AUQ) adapted from Mills et al. (1983); Childhood Hyperactivity Questionnaire (HK/MBD; Tarter et al., 1977); Eysenck Personality Questionnaire (EPQ; Eysenck and Eysenck, 1975); Socialization Scale (SSQ) of the California Psychological Inventory (Gough, 1960).

Beverage administration

Results of a pilot study conducted prior to the experiment suggested that 0.4 g of 100% ethanol per kg of body weight, Smirnoff vodka 40% alcohol, mixed with chilled grapefruit juice and pineapple-orange-guava frozen concentrate in a 1:5.5 ratio, successfully disguised the taste of alcohol. The beverage administration procedure was adapted from Rohsenow and Marlatt (1981) and included the cues (e.g., vodka bottle) appropriate to the instructional "expectancy" condition. In both "told alcohol" conditions a premeasured amount of either vodka (in GATA condition) or water (in GJTA condition) was poured from a Smirnoff vodka bottle and mixed, in subject's view, with the fruit juice in a glass pitcher. In the GJTA condition strong olfactory cues were provided by a small piece of vodka-saturated gauze placed in the cap of the bottle unbeknownst to the subjects.

Task

Subjects were instructed to memorize a list of 20 words that were exposed for 300 msec at a rate of one word every 4 seconds. The words were presented individually in the center of a black and white computer-driven 24" TV screen within a visual window subtending an angle of 3-5°. At all other times, a fixation target consisting of five star characters was shown at the same screen location. In the recognition task that followed, 10 words from the initially memorized list were randomly chosen as "target" words and were presented on half of the total of 200 trials, mixed in among the new unlearned words. Subjects were instructed to press a microswitch every time one of the originally memorized words appeared on the screen. Responding hands alternated semi-randomly between the sessions. A feedback tone (sawtooth waveform), 100 msec duration, occurred 1500 msec after word onset informing the subjects whether their response was correct (high pitch = 500 Hz) or not (low pitch =100 Hz). All the words were four to six letters long, equated across lists on their imagery, concreteness and frequency of occurrence on the basis of published norms (Francis and Kucera, 1982; Paivio et al., 1968). The words had low frequency of occurrence (one to seven per million) and were presented in a random order. A different set of words was used in each session in a randomized manner.

The task difficulty ratings obtained on a 1-5 Likert scale at the end of each experimental session indicated that the task was perceived as very to moderately easy (mean [±SD] = 1.71 ± 0.87). The ratings were not influenced by the factors of beverage or instructions nor did they become progressively easier or more difficult across the recording sessions.

Recording of event-related potentials

The electroencephalogram (EEG) was recorded with a lycra fitted electrode cap (Electro-Cap International, Inc., Eaton, OH) from 13 scalp sites: Fz, Cz, Pz, F3, F4, F7, F8, C3, C4, P3, P4, T5, T6 of the 10-20 International system. An electrode placed on the tip of the nose served as the reference and one on the right earlobe as ground. The electrooculogram (EOG) was recorded with bipolarly referred electrodes placed at the outer canthus of the right eye and just above the nasion. The electrode impedance was kept below 5 kOhms. The EEG and EOG were recorded with a Grass 16-channel polygraph with DC amplifiers set at .8 sec time constant and with a bandpass of 0.05 to 75 Hz (1/2 amplitude). EEG and EOG data for each trial were digitized at a rate of 200 Hz (5 msec per point) with 12-bit accuracy and stored on an IBM-PC compatible computer for off-line analysis. EEG data sampling began 100 msec before each word onset and continued for 2660 msec.

Results

Behavioral measures

Repeated measures ANOVAs were performed on the data of 11 subjects, as the behavioral data of one subject were not available for all four sessions. The analysis revealed no significant effects of beverage, instructions, hand or session order on the reaction time (RT) averaged across trials with correct responses. On average (±SD), the subjects responded 641.45 ± 68.5 msec after stimulus presentation onset. Recognition performance was nearly perfect with 98.3% ± 1.8 mean correct responses and was not affected by any of the factors.

In addition to the verbal memory task, the subjects performed a simple tone discrimination task—an "oddball" paradigm with easily discriminable frequent nontarget, rare target and rare deviant tones. Subjects were instructed to press a button upon detection of the target tone. RTs obtained in this nondemanding paradigm probably reflect the speed of simpler psychomotor processes. In contrast, the verbal task requires involvement of more complex word memory processes, resulting in longer reaction times. It can be hypothesized that the difference in RT between the two tasks may be due to activation of the higher brain functions related to verbal perception and memory when they are corrected for psychomotor speed. In order to test this hypothesis, a within-subject ANOVA was performed on the difference scores obtained by subtracting RTs in tone discrimination from RTs in the verbal memory task for each of 11 subjects.

Although there were no beverage effects on RT in either task when analyzed separately, the difference RTs were affected by the type of beverage ($F = 9.23$, 1/10 df, $p < .05$). In alcohol conditions, the average RT difference between two tasks was only 14.6 msec. When given juice, the difference was 77.8 msec. This result appears to be caused by a decrease in RTs in the word task when alcohol was consumed (Figure 1). It seems that in the verbal memory task the subjects reacted more hastily and, perhaps, more impulsively when given alcohol than when given juice. The beverage effect in the word task per se was not significant ($F = 2.03$, 1/10 df, $p = .18$).

Lateralized readiness potentials (LRP)

All trials in which incorrect responses were made, or in which eyeblinks or other artifacts occurred, were eliminated from the analyses. The overall mean (±SD) number of trials retained in averages of new and repeated words was 90.8 ± 5.1 and 91.2 ± 6.9, respectively. Average waveforms were obtained for each level of the within-subject factors: task condition (new and repeated words), beverage (given juice or alcohol), responding hand (left and right) and for each electrode site.

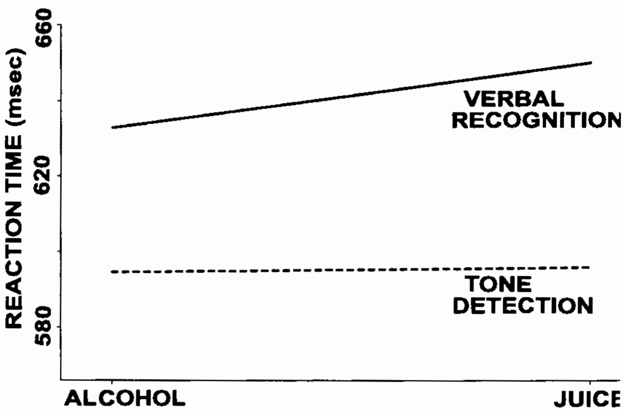

FIGURE 1. A comparison of average reaction times recorded during verbal recognition task and tone detection ("oddball") task. Alcohol intoxication exerted a significant effect on the RT difference scores obtained by subtracting RT in the tone detection task from the RT in verbal recognition task. This effect is due to a tendency to respond faster to repeated words when mildly intoxicated.

An investigation of the bilateral LRP was permitted by counterbalancing the responding hand across sessions. However, the factors of beverage and responding hand were not orthogonal for three subjects. Consequently, the analyses were performed for nine subjects for whom the two levels of the beverage factor were crossed with both responding hands. The movement-related LRPs were obtained by a two-step procedure (Coles, 1989): (1) averaged scalp potentials recorded over Rolandic areas ipsilaterally to the responding hand were subtracted from the contralateral potentials (e.g., C3-C4 for right-hand responding); (2) the subtracted lateralized measures obtained for left and right hands were averaged together.

The LRP was quantified by measuring average voltages over C3 and C4 within the latency window 100-600 ms post-stimulus onset in 100 ms increments. All measures were expressed in microvolts (amplitudes) and milliseconds (latencies) with respect to a baseline period of 100 msec before stimulus onset. Repeated measures ANOVAs with factors—beverage (GA, GJ), stimulus (new vs repeated) and responding hand (left, right)—were performed on all of the average voltage measures obtained over C3 and C4. Since there were no effects of the instructions as to the beverage content, the data were summed across the factor of instructions.

Average LRPs obtained on trials in which the subjects responded correctly to repeated target words, or correctly withheld a response to nonsignal novel words, are presented in Figure 2 with superimposed potentials obtained in alcohol and placebo conditions. The movement-related negativity starts earlier and appears to be larger when alcohol was imbibed, as compared to placebo, for both target and novel words. Indeed, the main effect of beverage becomes significant in the 400-500 ms latency range ($F = 6.1$, 1/8 df, $p < .05$). A closer look at these effects reveals that this main effect is due to the alcohol-placebo difference on novel, nonsignal trials. The effect of beverage on the target trials does not reach significance in any of the examined latency windows. In contrast, the novel words consistently evoked a larger negativity in alcohol condition, as compared to placebo, in 200-500 ms range ($F = 10.2$, 1/8 df, $p < .05$).

A decision whether to press a button or not could be made only after the appropriate level of semantic and mnestic analysis was reached. Target "go" words required a motor response, and a large bilateral movement-related negative potential indexing preparatory brain activity can be observed in Figure 2a. This negativity preceding the response did not differ significantly between the alcohol and juice conditions. Since the novel "no go" words did not require a response, no movement-related activity was necessary. Consistent with such a requirement, novel words did not evoke any negativity in the placebo condition. In contrast, mild inebriation resulted in a motor preparation for a response on "no go" trials

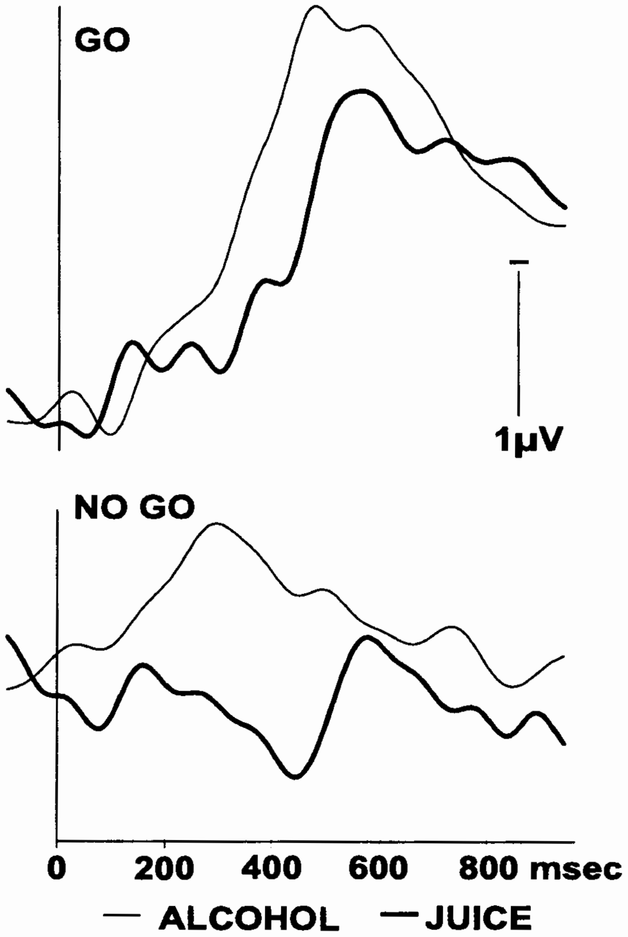

FIGURE 2. Grand averages of movement-related Lateralized Readiness Potentials recorded from central sites (C3 and C4) obtained to "go" target words (Figure 2a: top panel) and to "no go" novel words (Figure 2b: lower panel) with correct responses or response abstentions, respectively. Waveforms obtained in alcohol and juice conditions are superimposed. Novel "no go" words consistently evoked a larger negativity in alcohol condition, possibly suggesting a tendency for impulsive reactions.

(Figure 2b). Since only correct responses to targets and correctly withheld responses to novel words were included in ERP averages, motor preparation started before the decision could be reached whether the word was "go" or "no go." When the processing sequence necessary to arrive at such a conclusion was carried out, the motor preparation was correctly interrupted before the motor response was actually executed (Figure 2b).

Lateralized event-related spectral power (LERSP)

In addition to analyzing the movement-related potentials in time domain, the same data were submitted to the analysis of spectral power in frequency domain in order to assess the task and beverage effects on the Rolandic mu-rhythm. Spectral power was measured with discrete Fourier transform applied to EEG epochs from individual trials and spectral averages were obtained for each subject and for each condition. The same general procedure used for obtaining the LRP (in time domain) was followed for LERSP (in frequency domain). For the purposes of statistical analysis, LERSP was measured as the square root of power and baseline-normalized at the peak of the power spectrum that fell within the range of mu, at the frequency of 15 Hz (12.5 to 17.5 Hz range). The power spectra were obtained for two time windows: 200-400 msec and 400-600 msec poststimulus onset and analyzed with 2 × 2 ANOVAs with the factors of repetition (new and repeated words) and beverage (alcohol and juice) (Figure 3).

Within the 200-400 msec time window, LERSP decreased to the new words in the alcohol condition ($F = 7.6$, 1/8 df, $p < .05$) as compared to placebo. A similar result was obtained for the 400-600 msec time window ($F = 11.7$, 1/8 df, $p < .01$). No effect of beverage was observed for the repeated words. These effects of alcohol mirror the results obtained on LRPs in time domain as a larger mu-rhythm decrease in LERSP was observed under alcohol on "no go" trials. Given that interruption of the mu-rhythm indicates motor preparation (Chatrian, 1976), this provides further evidence for an alcohol-evoked readiness to prematurely engage the motor-response system.

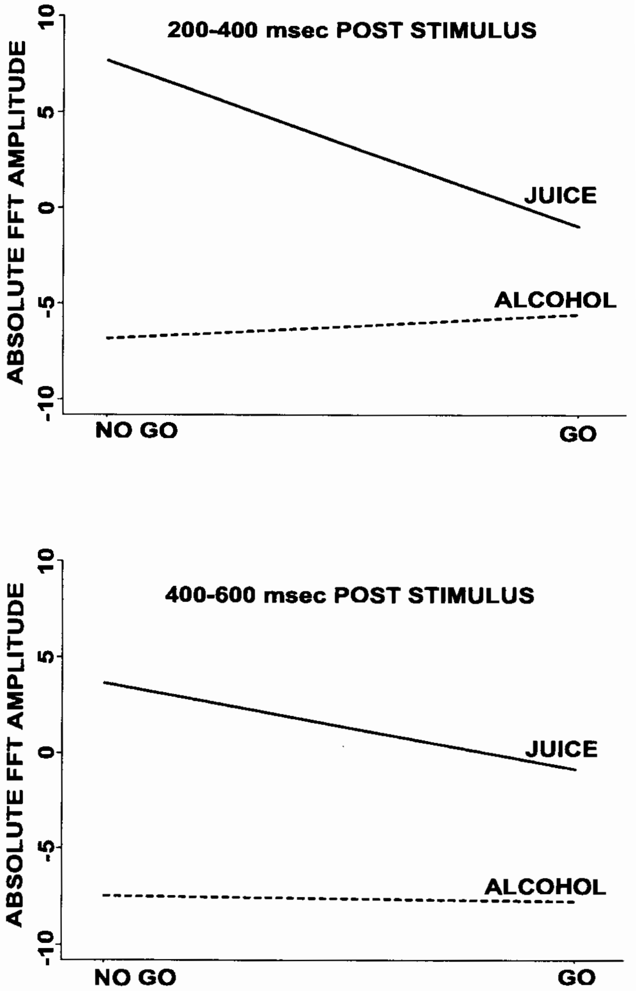

FIGURE 3. A juice vs alcohol comparison of Lateralized Event-Related Spectral Power (LERSP) expressed as absolute FFT amplitude for "no go" novel words and "go" target words for the two latency windows 200-400 msec post stimulus onset (top panel) and 400-600 msec (lower panel). Novel "no go" words evoked a decrease in LERSP of mu-rhythm in alcohol condition, suggesting an inappropriate and premature engagement of a movement preparation system.

Personality and LRP

Based on reports of significant correlation between impulsivity and drinking problems (Nagoshi et al., 1991; Regier et al., 1990), an attempt was made to analyze the present data in a similar manner by examining the interdependency between the alcohol-related difference in LRP on the "no go" trials (a potential physiological index of impulsivity) and personality measures available on the same subjects. Pearson correlation coefficients were calculated between the alcohol-related LRP difference (obtained by subtracting the average LRP in juice from the average LRP recorded in alcohol conditions) and the following personality indices: the three dimensions of the Eysenck Personality Questionnaire (psychoticism, extraversion, neuroticism), the socialization index (SSQ) and childhood hyperactivity (HK/MBD).

Due to its small size, this data set is not well suited for the correlation approach as both physiological and personality questionnaire data were available for only eight subjects. However, some correlations between the alcohol-related LRP in the first 300 ms after stimulus onset and the available questionnaire-type measures of impulsivity were observed. Bonferroni corrected (Bonf. *p*) probability values were obtained by multiplying the uncorrected *p* value by 5 (5 personality scales). Individuals who exhibited a larger alcohol-induced average LRP to novel ("no go") words within 100-200 ms latency had higher scores on the childhood hyperactivity (HK/MBD) scale ($r = 0.77$, $p < .026$, Bonf. $p < .13$). In addition, the alcohol-related LRP difference was positively correlated with psychoticism ($r = 0.84$, $p < .01$, Bonf. $p < .045$). Similarly, within 200-300 ms latency, alcohol-evoked LRPs on novel trials correlated positively with indices of psychoticism ($r = 0.8, p < .017$, Bonf. $p < .085$) and childhood hyperactivity (HK/MBD; $r = 0.86$, $p < .007$, Bonf. $p < .035$), and negatively with socialization ($r = -0.8, p < .017$, Bonf. $p < .085$). The measure of lateralized spectral power exhibited a trend toward a correlation with the socialization scale ($r = 0.68$, $p < .06$, Bonf. $p < .3$). Although most of these correlations were rendered insignificant by a Bonferroni correction for multiple comparisons due to very low power, the r values indicate that these personality traits related to impulsivity shared about 60% or more of the variance with the alcohol-induced LRP on "no go" trials.

Discussion

Lateralized Readiness Potential is an electrophysiological index of asymmetry primarily related to the activation of precentral and premotor cortices contralateral to the side of the movement. The LRP is derived by averaging the movement-related asymmetries for the two hands, thus eliminating any activity unrelated to the side of the movement. It has been established that a large LRP develops on "go" trials accompanied by an overt motor response (Coles et al., 1988). However, LRP has also been recorded on "no go" trials (Smid et al., 1995), even without any concurrently recorded muscular activation (Osman et al., 1992). The LRP derivation obtained in the present study during a simple verbal recognition task predictably showed a large movement-related negativity on target "go" trials. This motor-related potential did not differ significantly between the juice and alcohol conditions. No LRP was observed to novel "no go" words in the juice condition. However, alcohol inebriation resulted in an LRP recorded on novel, nontarget "no go" trials that peaked, on average, at about 300 msec after stimulus onset and then returned to baseline. The LRPs were based on the artifact-free trials in which the subjects correctly responded to target words and correctly withheld responses to novel words. Nevertheless, a hand-specific motor preparation was initiated and was correctly terminated when alcohol was imbibed even in those trials that did not require and did not elicit overt responses. Clearly, in this "go/no go" situation, an appropriate initiation of a motor response should not start before a word stimulus has been analyzed sufficiently as to ascertain whether it is a target requiring a response, or it is a novel word signalling a response inhibition. Accordingly, no response preparation to novel "no go" words was initiated in juice condition. Yet, in the alcohol condition, the word presentation itself, rather than its completed analysis, triggered a motor preparatory sequence. Since the responding hand was held constant throughout each recording session it is likely that the responding mechanisms were primed even before the onset of a stimulus (Gratton et al., 1988) and that the LRPs on "no go" trials were elicited automatically, upon a stimulus detection in the alcohol condition. Thus, the data suggest an inappropriate premature response preparation based on insufficient and preliminary stimulus analysis (Osman et al., 1992) which may be indicative of impulsive and hasty responding under the influence of alcohol. This interpretation is supported by the evidence that in "go/no go" tasks using simpler stimuli, short-latency responses are accompanied by larger LRPs (Gratton et al., 1988; Smid et al., 1995). Such "fast guesses" are characterized by an advanced preparation to respond (Coles et al., 1988; Hackley and Miller, 1995).

The tendency to respond more hastily under the influence of alcohol was confirmed by the reaction time data. Whereas alcohol did not affect accuracy in this task, it significantly shortened reaction time after it was adjusted for psychomotor speed. Although most studies report increased RT under alcohol (Franks et al., 1976), an inverse relationship between RTs and BAC was reported by Landauer and Howat (1983), suggesting impulsive responding under the influence of alcohol.

A possibility that an LRP on "no go" trials in the alcohol condition was due to increased task difficulty (Osman et al., 1992) rather than "impulsivity" is not supported by the available evidence: the overall percentage of response errors was very low (<2%) and was unaffected by the beverage; subjects did not rate the task as being more difficult under alcohol; the LRP in juice conditions was absent and not relatively smaller compared to alcohol.

Similar to the LRP results, the frequency domain analysis indicated that alcohol inebriation resulted in a decrease of LERSP (indicating larger desynchronization) of the mu-rhythm for the "no go" words only. Previous studies have shown that larger mu-rhythm desynchronizations precede brisk movements resulting from stronger muscle contractions (Stancak and Pfurtscheller, 1996). Thus, the current LERSP results can also be interpreted as indicating that the motor response system may be prematurely engaged under low doses of alcohol.

Increased impulsivity under the influence of alcohol has been likened to disinhibition. It has been suggested that long-term alcohol use results in disinhibited motor behavior. Parsons et al. (1972) reported that chronic alcoholics were unable to suppress fast responding in a task that required slow motor control. A rather low alcohol dose (peak BAC of 0.04%) administered to social drinkers significantly reduced the latency to the onset of penile tumescence while listening to an erotic tape (Wilson and Niaura, 1984). These effects may result from the general psychomotor stimulant properties of alcohol (Wise, 1988) and may be related to an impairment in frontal control of behavior (Peterson et al., 1990).

The possible use of the LRP as a physiological index of alcohol-induced impulsiveness is further supported by the correlational data obtained in this study. Due to the small sample size these data should be considered preliminary and will need to be replicated. Nevertheless, correlation trends were obtained between the alcohol-induced LRP on "no go" trials and personality traits such as childhood hyperactivity, psychoticism (Eysenck's P) and socialization, with the common variance of 60% or more. Impulsivity/disinhibition as a reversal of suppression of behavior is a construct that is very difficult to operationalize and measure directly. Yet, it seems to have been measured indirectly as an underlying factor in the aforementioned traits measured in this experiment. Those participants who, when intoxicated, inappropriately exhibited the largest LRP on "no go" trials, also had higher scores on the traits related to hyperactivity/impulsivity and antisocial tendencies. These traits form a cluster termed "antisocial personality disorder" (Sher and Trull, 1994) that correlate highly with chronic alcohol use (Regier et al., 1990). Nagoshi et al. (1991) reported a significant correlation between impulsivity and self-reported alcohol use, as well as drinking problems, in a large sample. Underlying commonalities between impulsivity and alcohol abuse are also substantiated by their shared neurochemical markers (Virkkunen and Linnoila, 1993; Zuckerman, 1993). This may be suggestive of a preexisting neurochemical milieu in certain individuals that is associated with a set of overt behaviors commonly described as impulsive, hyperactive and even aggressive and which, in turn, is susceptible to alcohol (Pihl et al., 1993).

In conclusion, the current study demonstrates a premature and inappropriate activation of the motor-response system under low levels of alcohol using two physiological measures, the lateralized readiness potential and the mu-rhythm. The former measure correlates with personality factors that have been associated with impulsiveness, suggesting that it may be used as an on-line physiological index of preparedness to act impulsively and as a tool to investigate abnormal information processing under alcohol.

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