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## Alcohol and Erectile Response: The Effects of High Dosage in the Context of Demands to Maximize Sexual Arousal

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### Abstract

Although drinking is often associated with men's sexual activity, basic questions about alcohol's effects on men's sexual arousal remain unanswered. Inconsistencies in findings from studies examining subjective and physiological effects on erectile functioning suggest that alcohol's effects are context specific, e.g., dependent on whether one wants to maximize or suppress his arousal. To address unresolved questions about alcohol and erectile functioning, two experiments evaluated the effects of high blood alcohol concentrations (BACs) and arousal instructional demands on indices of penile circumference change and self-reported sexual arousal. In Experiment 1, a target BAC of .10% (versus .00%) attenuated peak circumference change from a neutral baseline but had no effects on average change, latency to arousal onset (a 5% increase in circumference from baseline), latency to peak achieved arousal, or subjective arousal. Instructions to maximize arousal (versus no instruction) increased subjective arousal, which was moderately correlated with physiological indices. In Experiment 2, instructions to maximize (versus suppress) arousal increased peak and mean circumference change and interacted with a target BAC of .08% (versus .00%) to influence latency to arousal onset: sober men instructed to maximize showed a shorter latency to arousal onset than did sober men instructed to suppress; however, intoxicated men did not show a differential pattern. Moreover, compared to intoxicated counterparts, sober men instructed to maximize showed a marginally shorter latency to arousal onset. Overall, alcohol and arousal instructions had small but discernible effects with young moderate drinkers. Findings highlight the importance of contextual factors in alcohol's impact on erectile functioning.

### Keywords

alcohol; sexual arousal; erectile dysfunction; erection; penile plethysmography

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Alcohol is often linked with men's sexual activities (Crowe & George, 1989; George & Stoner, 2000); and erectile functioning has inherent relevance to understanding this link. Yet

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alcohol's physiological effects on erectile functioning have not been fully explicated. Despite initial evidence to the contrary, high blood alcohol concentration (BAC) – particularly .08% and above (Briddell & Wilson, 1976) – does not seem to attenuate erectile tumescence reliably (Morlet et al., 1990). This apparent contradiction underscores the need for further research. Also, research about men's voluntary control over their erectile responding raises the possibility that alcohol's effects are context specific, particularly concerning a man's attempt to maximize his arousal (Barlow, 1986). To investigate this possibility and further elucidate alcohol's effects, we investigated the interaction between high BAC and instructions to maximize arousal, compared with neutral instructions (Study 1) or with opposing instructions to suppress arousal (Study 2).

## Alcohol and Erectile Attenuation Effects

Three of four experiments published 30 years ago showed that high doses of alcohol attenuated erectile response (Briddell & Wilson, 1976; Farkas & Rosen, 1976; Rubin & Henson, 1976). Attenuation effects also emerged in three subsequent experiments (Wilson, Lawson, & Abrams, 1978; Wilson, Niaura & Adler, 1985; Wormith, Bradford, Pawlak, Borzecki, & Zohar, 1988) and a case study (Cooper, 1994). Alcohol-induced attenuation of genital arousal seemed conclusive. However, eight studies have revealed null effects. In five balanced placebo studies manipulating alcohol and alcohol expectancy set independently, no attenuation effects were found (Abrams & Wilson, 1983; Briddell et al., 1978; Lansky & Wilson, 1981; Wilson & Lawson, 1976; Wilson & Niaura, 1984). These null effects have been attributed to the low BACs (.03 - .05 mg %) required in balanced placebo studies; yet attenuation has been observed at comparable dosages in other work (Briddell & Wilson, 1976; Farkas & Rosen, 1976). Null effects have also occurred in two studies with similar and higher BACs: .056 mg % (Abrams & Wilson, 1983) and .104 mg % (Langevin et al., 1985). Finally, Morlet et al., (1990) investigated nocturnal penile tumescence, evaluating the highest dosages reported (.15 mg% and .18 mg%), and found no attenuation. Thus, the attenuation effect is far from universal, having occurred in fewer than half of studies on alcohol and erectile response (George, Norris, & Schacht, 2003).

Inconsistent findings have been attributed mainly to three methodological problems. First, George and Stoner (2000) noted variability depending on whether arousal was assessed on the ascending versus descending limb of the blood alcohol absorption cycle. In studies where BAC was assessed only once (Rubin & Henson, 1976), estimates about BAC limb during arousal assessment were entirely speculative, thereby obscuring alcohol's effects. Even in studies where BAC was assessed twice, the limb during which arousal was measured could not be determined unequivocally (Lansky & Wilson, 1981). Second, Langevin et al. (1985) noted that use of within-subject designs potentially confounds attenuation with an implicit demand to respond differently when intoxicated versus sober. Third, the same authors also noted that repeated use of the same erotic stimuli potentially confounds attenuation with habituation to the erotic stimuli. Further work overcoming these problems is necessary to clarify the putative attenuation effect of intoxication on erectile response.

## Context: Voluntary Control and Instructions to Maximize Arousal

The context of instructions or conditions conveying a demand to become highly aroused has proven essential to understanding erectile functioning generally (Barlow, 1986). Likewise, this psychological context would seem important to clarifying alcohol's attenuating effects. However, no such experimentation has been reported thus far. Research unrelated to alcohol has shown that, despite initial impressions that perhaps men could not exert voluntary control over autonomically innervated erectile structures, sexually functional men can

indeed control their erection in response to instructional demand (Hatch, 1981). Specifically, men show higher arousal levels under instructions to become highly aroused than control instructions (Barlow, 1986; Rubin & Henson, 1976). These findings show that sexually functional men can exert voluntary control over sexual responding; that is, they are capable of consciously enhancing their erectile response to erotic stimuli.

Cognitive mechanisms have been implicated both in voluntary erectile control and in alcohol's effects on sexual arousal. While it is not completely understood how men achieve erectile control (Beck & Baldwin, 1994), the general conclusion has been that control is achieved cognitively. In the absence of physical manipulation or gaze diversion tactics (typically prohibited in studies of erectile control), it seems likely that men exercise control over their arousal by managing their internal cognitive experience (Barlow, 1986). Alcohol intoxication disrupts cognitive capabilities and may thereby indirectly affect voluntary control of erectile responding. Wilson et al. (1985) found that alcohol's attenuation effects on penile tumescence were moderated by simultaneous engagement in a high demand cognitive task. Men in this study had not been instructed to maximize their arousal *per se*. Nevertheless, the findings were consistent with the possibility that moderate intoxication coupled with diminished cognitive capability resulted in men being less effective at maximizing their arousal. Presumably, alcohol impairs cognitive functioning, which – in turn – compromises the ability to exert effective voluntary control over erectile functioning.

## Present Research and Methodological Issues

Study 1 tested a decidedly high BAC level (target = .10%), among the higher levels used with wakeful men in sexual arousal research, to provide a robust test of the attenuation effect. We contrasted maximize versus neutral instructions, which were intended to constitute an inert instructional context. In Study 2, we lowered BAC (target = .08%) seeking to identify a lower threshold of the attenuation effect and contrasted maximize versus suppress instructions, which were intended to constitute an opposing instructional context.

Methodological problems noted earlier were addressed. To specify BAC level and limb (George & Stoner, 2000), we assessed BAC numerous times and individualized the absorption period, yoking control subjects' absorption periods to those of intoxicated participants. To address Langevin et al.'s (1985) concern about attenuation being an artifact of an implicit demand to respond differently when intoxicated than sober, we used a between-subjects design. To address their concern about habituation to the erotic stimuli, we presented the stimuli only once. Finally, to consider arousal topography across multiple dimensions we included subjective, tumescence, and latency indicators. Altogether, erectile response was assessed across five response indices: self-report, peak circumference change, average circumference change, latency to change onset, and latency to peak circumference change.

### Study 1

Main and interaction effects were hypothesized. Despite supportive and nonsupportive evidence for attenuation effects previously, the weight of the data and extant conclusions predict alcohol-induced attenuation at high dosage (Crowe & George, 1989; George & Stoner, 2000). Non-alcohol studies indicate that provision of an instruction or a demand to become highly aroused produces more arousal than do control conditions. Heiman & Rowland (1983) found that compared to a “sensate focus” instruction to “relax and enjoy,” a demand instruction to become highly aroused led sexually functional men to increase arousal. Beck, Barlow, & Sakheim (1983) created high and low demand with videotapes depicting a partner as highly aroused or as less aroused; they found that functional men in

the high demand condition exhibited more arousal than counterparts in the low demand condition. We hypothesized an interaction whereby alcohol would qualify effects for instructional demand. Because of impairing effects on men's capacity to marshal cognitive resources necessary for voluntarily maximizing arousal, alcohol should reduce effectiveness at maximizing arousal. Compared to sober men, intoxicated men should experience cognitive impairment and, as a result, be less able to show voluntary control by responding differentially to maximize versus control instructional demands.

## Study 1 Method

**Participants**—Men ( $n = 65$ ) were recruited from a large, urban university and the community at large through flyers, newspaper advertisements, and letters, which stated that the study involved “social drinking and decision-making.” Potential participants (Ps) called the laboratory and were told that procedures included the use of sexually explicit films and physiological measures of sexual arousal, and were screened to determine whether they were eligible to participate. Inclusion criteria were that the individual had to be (a) between the ages of 21 and 35; (b) interested in dating opposite-sex partners; (c) not currently in a committed dating relationship; and (d) a moderate drinker. Exclusion criteria were current problem drinking or a history of problem drinking<sup>1</sup> and/or currently taking medications or having a health condition contraindicated with alcohol consumption. Ps received \$15 per hour for study participation.

Ps' mean age was 25.6 years ( $SD = 3.9$ ). Ps were predominantly European-American (69.2%); 6.2% were African-American, 3.1% were Latino, 3.1% were Asian, and 18.3% were multi-racial or other. Approximately two-thirds (62.5%) were employed, with 66.7% reporting an annual income of less than \$31,000/year. Ps' self-reported typical drinking levels were 17.02 ( $SD = 9.87$ ) drinks per week, on average. Fewer than one-half (41.9%) were college students.

### Measures and materials

**Stimulus films:** Ps viewed a sexually-neutral 2.5-minute long documentary about birds, followed by two three-minute erotic films. Pilot testing established that these films induced equivalent self-reported increases in sexual arousal (George, Zawacki et al., 2003). Both erotic films, which were commercially available, explicitly depicted normative, consensual sexual activities (kissing, oral sex, and vaginal intercourse) between an adult man and an adult woman.

**Physiological sexual arousal:** Sexual arousal was measured with penile plethysmography (BioPac Systems, Inc., Santa Barbara, CA; model MP 150) and a mercury-in-rubber strain gauge (D. M. Davis Inc. Hackensack, NJ) positioned mid-shaft on the penis (E. Janssen, personal communication, July 2002). Using Acqknowledge software (version 3.7.2), data were collected at a rate of 62.5 samples per second then further reduced to 25 samples per second. To ensure accurate measurement, strain gauges were calibrated prior to each use by placing the gauge on a calibration cone and adjusting size values in the software to equal the known size of each gauge. Gauges were disinfected following each use with Cidex OPA solution (Advanced Sterilization Products, Irvine, CA). Movement artifacts, defined as clear spikes of more than 5 mm in an otherwise smooth curve, were deleted based on visual

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<sup>1</sup>Potential participants were excluded if they reported having been (a) told by a professional that they had problem with alcohol, (b) ever seriously concerned about their own drinking, or (c) treated or advised to seek treatment for drinking. They were also excluded if they had ever experienced any of the following after drinking alcohol: (a) fainting or seizure, (b) highly unusual flushing of the skin, or (c) severe or unusual psychological reaction. Potential participants were also excluded if they reported average consumption greater than 40 drinks/week. Finally, those who reported a positive family history for alcoholism and average consumption near 40 drinks/week were also excluded.

inspection of raw data records (Janssen, personal communication, May 2002). Data were then digitally transformed. Movement deletion decisions were checked and affirmed in both analogue and digital data and data were exported to a data analytic program for analysis (Hoffmann, Janssen & Turner, 2004).

**Self-reported ratings of sexual arousal:** Ps rated their perceived level of arousal after the film clips on a 4-item seven-point Likert scale (1 = “no sexual arousal at all”; 7 = “extremely sexually aroused”). Items were adapted from previous research and included: (1) “Overall, how much sexual arousal did you feel during the film clips?” (Heiman, 1977); (2) “To what extent did you feel sensation in your genitals during the film clips?” (Heiman & Rowland, 1983; Reynolds et al., 1988) “How much sexual warmth (in your genitals, breasts, and body) did you feel during the film clips?” (Meston, Heiman, Trapnell, & Paulhus, 1998); (4) “To what extent did you feel sexually absorbed in the sensory components of the film clips?” These four items were combined to form a sexual arousal scale with good inter-item reliability ( $M = 5.09$ ,  $SD = 1.24$ ,  $\alpha = .92$ ).

**Balanced Inventory of Desired Responding (BIDR):** This 40-item measure was used to assess social desirability. Items are based on a 7-point Likert scale, and include: “I sometimes tell lies if I have to,” “I never read sexy books or magazines,” and “I sometimes drive faster than the speed limit.” This measure has acceptable reliability ( $\alpha = .83$ ; Paulhus, 1991; Study 1 sample  $\alpha = .82$ ; Study 2 sample  $\alpha = .75$ ).

**Manipulation checks:** To determine whether participants had been aware of the sexual arousal instructional set that they had been assigned to, manipulation checks were administered following the sexual arousal assessment. Participants were asked, “Prior to viewing the erotic film clips, were you instructed to suppress your arousal? (yes/no/don't know).”

## Procedure

**Pre-experimental instructions:** During the screening phone call, participants were instructed to bring photo identification, not to drive to the laboratory, not to eat or consume caloric drinks for three hours before their appointments, and not to drink alcohol or use recreational or over-the-counter drugs for 24 hours before their appointments.

**Initial procedures:** Each participant was conducted through the study procedures by a male experimenter. Upon arrival, each participant was escorted to a private room, where the experimenter administered a blood alcohol level (BAL) test with a breathalyzer (Alco-Sensor IV, Intoximeters Inc., St. Louis, MO) to ascertain a zero reading. Participants with a positive reading were rescheduled and dismissed. After confirming that the participant had complied with all pre-experimental instructions, the experimenter obtained informed consent. Participants were then left alone to complete background questionnaires.

**Alcohol procedures and administration:** Each P was randomly assigned to an alcohol condition and was weighed to determine the amount of 190-proof grain alcohol needed to achieve a BAL of .10% (dosage = 1.25 ml alcohol/kg body weight). Drinks consisted of one part alcohol to six parts fruit juice. In order to ensure that the assessment took place on the ascending limb of alcohol intoxication, Ps' BALs were tested every three minutes until they reached criterion ( $BAL \geq .06$ ), at which point they began the sexual arousal assessment. Mean pre-assessment BAL was .069 ( $SD = .011$ ). Ps took on average 26 minutes ( $SD = 10$ ) post-drinking to reach the target BAL. No-alcohol Ps drank a volume of juice equivalent to what they would have received in the alcohol condition. A yoked control design was used to reduce error variance in intoxication levels and to control for differences in the time it took

individual alcohol Ps to reach the criterion BAL (George et al., 2004; Giancola & Zeichner, 1997). Control Ps were yoked to an alcohol P who had already participated, and were breathalyzed and began the dependent measures at the same time intervals as did their alcohol yoke.

**Sexual arousal instructional set:** Ps were randomly assigned to a maximize-arousal instructional set condition or a no-instruction control condition. Experimenters were blind to Ps' arousal instruction condition. After the neutral film, Ps received audio instructions over headphones informing them of their arousal instruction and directing them to open an envelope containing a card reiterating this instruction. In the maximize condition, the instructions were to "try as much as possible to relax and maximize your arousal during the remainder of the experiment. We would like you to try and become as aroused as possible." In the control condition, the instructions were to "Remember: Try to stay as still as possible."

**Sexual arousal assessment:** Prior to providing beverages, the experimenter instructed the P in the proper placement of the gauge. After Ps consumed their beverage and reached criterion BAL, the experimenter restated the gauge placement instructions by intercom, and the P placed the gauge. The experimenter monitored the physiological signal via computer in a separate room. After a 1-2 minute baseline reading, the P was shown the neutral film clip. A final pre-arousal BAL assessment was taken by the experimenter after the neutral clip. Ps were then shown the two erotic films, after which they rated their level of sexual arousal. Following the sexual arousal assessment, they were instructed by intercom to remove the gauge and get dressed.

**Detoxification and debriefing:** Control Ps were debriefed, paid, and released upon completion of the experiment. Alcohol Ps were escorted to another room, where they remained until their BAL dropped to .03, at which point they were debriefed, paid, and released. During debriefing, all Ps were given the opportunity to ask questions and to discuss any discomfort they might have experienced during the protocols.

## Study 1 Results

**Data Analytic Strategy**—Analysis of variance (ANOVA) tests examined the effects of alcohol condition (control vs. .10%) and arousal instructional set condition (maximize vs. control) on four penile plethysmography variables. The first variable, peak percentage circumference change from the neutral stimulus baseline, was computed by subtracting each P's lowest achieved millimeter circumference during the neutral stimulus from his highest achieved millimeter circumference during the erotic stimulus and then dividing that amount by his lowest achieved millimeter circumference during the neutral stimulus multiplied by 100. The second variable, mean percentage circumference change from neutral stimulus baseline, was computed by subtracting each P's mean millimeter circumference during the neutral stimulus from his mean millimeter circumference during the erotic stimulus and then dividing that amount by his mean millimeter circumference during the neutral stimulus multiplied by 100. The third variable, latency to arousal onset, counted number of seconds from the beginning of the erotic stimulus until each P achieved a 5% increase in millimeter circumference from baseline levels. The fourth variable, latency to peak arousal, counted the seconds from the beginning of the erotic stimulus until each P achieved his peak level of arousal during the erotic stimuli. In the latency to peak arousal ANOVA, Ps' achieved peak millimeter circumference was entered as a covariate in order to control for differences in achieved peak arousal levels. Additionally, self-reported sexual arousal during the erotic stimuli was also examined with social desirability entered as a covariate. Data from 7 Ps were incomplete due to data collection problems and were not included in analyses.

**Penile Plethysmography Measures**—Consistent with the alcohol-induced attenuation hypothesis, there was a significant main effect of alcohol condition for peak percentage circumference change,  $F(1, 65) = 4.06, p < .05$ . Intoxicated Ps achieved a significantly lower peak percentage circumference change from baseline than did sober Ps. See Table 1 for means, standard deviations, and effect sizes. Contrary to prediction, the instructional main effect and the interaction were not significant.

There were no significant main effects or interactions for mean percentage circumference change from baseline, latency to arousal onset, or latency to peak arousal.

**Self-Reported Sexual Arousal:** For self-reported sexual arousal to the erotic stimuli, the main effect of arousal instructional set was significant,  $F(1, 65) = 5.56, p < .05$ . Ps instructed to maximize arousal reported significantly greater sexual arousal to the erotic stimuli than did Ps instructed to suppress their arousal. Contrary to predictions, the alcohol and interactive effects were not significant. Social desirability was not a significant covariate. Self-reported sexual arousal correlated significantly with peak percentage circumference change ( $r = .37, p = .001$ ), average percentage circumference change ( $r = .50, p < .001$ ), and latency to arousal onset ( $r = -.37, p = .001$ ). Self-reported sexual arousal was not significantly correlated with latency to peak arousal ( $r = -.15, p > .10$ ).

## Study 1 Discussion

A high alcohol dose did attenuate penile tumescence, as hypothesized. Men dosed to a target BAL of .10% exhibited less peak circumference change from baseline than sober controls. This is consistent with two previous findings based on comparably high dosages (Briddell & Wilson, 1976; Rubin & Henson, 1976). Also, our methods enabled us to overcome questions raised about previous findings concerning habituation to the erotic stimuli (Langevin et al., 1985), reliance on within-subject designs, and the timing of assessments on the BAL limb (George & Stoner, 2000). Nevertheless, the attenuation effect we obtained was confined to peak circumference. Mean circumference change and latency indices of circumference change were unaffected. Also, alcohol had no effect on self-reported arousal, even though self-reported arousal was correlated positively with circumference changes and negatively with change onset latency. Thus, alcohol's impact seemed very specific, dampening peak arousal with no commensurate impact on average response magnitude and reactivity. The picture that emerges is one of a limited but physiologically important alcohol effect, with men's self-perception of arousal being unaffected by alcohol intoxication. In the context of earlier null findings at higher dosages during a sleep study, the effects observed here are consistent with Morlet et al.'s (1990) suggestion that attenuation is not universal and that it hinges on conscious processing of erotic stimuli.

Surprisingly, instructional set had no effect on physiological arousal. This is inconsistent with previous findings. Heiman & Rowland (1983) found that maximize instructions increased arousal among sexually functional men. However, their control condition consisted of “sensate focus” instructions to “relax and enjoy,” which they reasoned may have actually functioned as an “anti-arousal message” in the context of an erotic film. Indeed, other studies using anti-arousal messages as the control condition have also yielded instructional set effects on physiological arousal (e.g. Adams, Motsinger, McAnulty, & Moore, 1992; Mahoney & Strassberg, 1991). Therefore, the control condition in the present study may have lessened the likelihood of an instructional effect precisely because we intended that the message be neutral. It may not have embodied a sufficiently anti-arousal message to generate the instructional set effect observed in previous work. This may also explain the failure to detect the hypothesized interaction between instructional set and alcohol on genital response. The instructional set conditions were not sufficiently different;



thus, there was no instructional set effect for alcohol to modify. Instructional set did influence self-reported arousal; however, this may reflect P compliance, reporting subjective levels of arousal that were consistent with what they were instructed to do.

Overall in Study 1, alcohol had a specific effect at a high dose, dampening peak tumescence; and the instructional sets seemed insufficiently differentiated to affect erectile responding. Study 2 was designed to intensify the instructional set differentiation and to explore the lower dosage boundary of the alcohol effect.

## Study 2

The main aim of the second study was to re-examine the intoxication-instruction interaction hypothesis in the context of more polarized instructional sets. Instructions to maximize arousal were set against instructions to suppress it. Again, alcohol and instructional main effects were anticipated as well as the interaction. Alcohol should impair men's capacity to marshal cognitive resources necessary for voluntarily controlling – maximizing or suppressing – arousal. Therefore, success in controlling arousal should be more evident among sober than among intoxicated men.

Another aim of Study 2 was to consider an alternative dosage level. Ethical and IRB constraints prevented examining a BAL higher than .10%. Therefore, we explored the lower dosage boundary of alcohol's attenuation effect. However, given the modest attenuation effects we obtained at a BAL of .10% in Study 1, we decreased dosage only slightly to a BAL of .08%.

### Study 2 Method

Study 2 was identical to Study 1 with the exception of the following.

**Participants ( $n = 60$ )**—Mean age was 25.0 years ( $SD = 3.9$ ). Ps were predominantly European-American (78.0%); 5.1% were Asian, 3.4% were African-American, 3.4% were Latino, 3.4% were Native American, and 6.8% were multi-racial or other. Over one-half (61.0%) were employed, with 72.9% reporting an annual income of less than \$31,000/year. Ps' self-reported typical drinking levels were 14.03 ( $SD = 10.11$ ) drinks per week, on average. Fewer than one-half (38.3%) were college students.

**Procedure**—Each P was weighed to determine the amount of 100-proof vodka needed to achieve a BAL of .08% (dosage = .82 ml alcohol/kg body weight). Drinks consisted of one part vodka to four parts fruit juice. Ps' BALs were tested every three minutes until they reached criterion ( $BAL \geq .045$ ), at which point they began the sexual arousal assessment. Ps' mean pre-assessment BAL was .059 ( $SD = .011$ ). Ps took on average 17 minutes ( $SD = 9$ ) post-drinking to reach the target BAL. No-alcohol Ps drank a volume of juice equivalent to what they would have received in the alcohol condition.

**Sexual arousal instructional set**—Ps were randomly assigned to one of two instructional set conditions, to either maximize or suppress their sexual arousal. In the maximize condition, the instructions were to “try as much as possible to relax and maximize your arousal during the remainder of the experiment. We would like you to try and become as aroused as possible.” In the inhibit condition, the instructions were to “try as much as possible to suppress your sexual arousal during the remainder of the experiment. In other words, please keep from becoming sexually aroused.”

## Study 2 Results

Identical analytic strategies were used in Studies 1 and 2. Data from 11 Ps in Study 2 were incomplete due to data collection problems and were not included in data analyses.

### Penile Plethysmography Measures

**Peak percentage circumference change from baseline:** As hypothesized, there was a significant main effect of arousal instructional set condition for peak percentage circumference change,  $F(1, 60) = 6.23, p < .05$ . Ps instructed to maximize their sexual arousal achieved a significantly higher peak percentage circumference change from baseline than did Ps instructed to suppress their sexual arousal. See Table 1 for means, standard deviations, and effect sizes. There were no other significant main effects or interactions.

**Mean percentage circumference change from baseline:** As hypothesized, there was a significant main effect of arousal instructional set condition for mean percentage circumference change,  $F(1, 60) = 7.30, p < .01$ . Ps instructed to maximize their sexual arousal achieved a significantly higher mean percentage circumference change from baseline than did Ps instructed to suppress their sexual arousal. There were no other significant main effects or interactions.

**Latency to arousal onset:** As illustrated in Figure 1, there was a significant two-way interaction,  $F(1, 58) = 6.25, p < .05$  between alcohol condition and instructional set. Sober Ps instructed to maximize arousal achieved a 5% increase in millimeter circumference from baseline significantly faster than did sober counterparts instructed to suppress arousal; however intoxicated Ps did not show this differential pattern. Additionally, the comparison of sober and intoxicated Ps' arousal onset when instructed to maximize approached significance ( $p < .06$ ): Sober Ps in the maximize condition achieved arousal onset marginally faster than intoxicated Ps in the maximize condition. There were no other significant effects.

**Latency to peak arousal:** As illustrated in Figure 2, the two-way interaction of alcohol condition and arousal instructional set approached significance,  $F(1, 60) = 3.01, p < .09$ . Sober Ps instructed to maximize arousal achieved peak millimeter circumference change from baseline faster than did sober counterparts instructed to suppress arousal; however, intoxicated Ps did not show this differential pattern. The covariate of peak millimeter circumference was not significant. There were no significant main effects.

**Self-reported Sexual Arousal—**For Ps' self-reported sexual arousal to the erotic stimuli, the main effect of arousal instructional set approached significance,  $F(1, 60) = 3.48, p < .07$ . Ps instructed to maximize arousal reported marginally greater sexual arousal to the erotic stimuli than did Ps instructed to suppress their arousal. No other main or interactive effects were significant. Social desirability was not a significant covariate. Self-reported sexual arousal correlated significantly with peak percentage circumference change ( $r = .31, p < .05$ ), average percentage circumference change ( $r = .45, p < .001$ ), and latency to arousal onset ( $r = -.45, p < .001$ ). Self-reported sexual arousal was not significantly correlated with latency to peak arousal ( $r = -.05, p > .10$ ).

## Study 2 Discussion

Surprisingly, there were no main effects for the .08% target BAL. Alcohol interacted with instructional demand, as hypothesized; but this was only evident on latency measures and not on circumference measures. Thus, Study 2 also showed confined alcohol effects. Previously, alcohol attenuation effects on penile circumference have been detected at

dosages as low as .05% target BAL (Farkas & Rosen, 1976; Rubin & Henson, 1976). However, critics have questioned those findings because of potential confounds concerning reliance on within-subject design (Briddell & Wilson, 1976; Langevin et al, 1985), habituation to the erotic stimuli (Langevin et al, 1985), and whether assessments were conducted on the ascending or descending BAL limb (George & Stoner, 2000). Attenuation effects on penile circumference have also been reported previously at the .08% target BAL, among studies characterized by one or more of these potential confounds (Barbaree, Marshall, Yates, & Lightfoot, 1983; Keltner & Doyle, 1986; Wormith et al. 1988). These problems were ruled out in the current study and no alcohol main effects were apparent. This suggests that alcohol attenuation effects on penile tumescence may be more limited than previously thought and that the threshold for these effects is somewhat higher than indicated by prior work. As noted earlier, effects do not appear to occur at all under conditions of sleep (Morlet et al., 1990).

Although no broad attenuation effects were evident, we did find interactions that were consistent with our proposition that alcohol affects men's capacity to control their erectile responding. There were two identifiable patterns. First, alcohol did not appear to interfere with men's conscious cognitive processes associated with voluntarily maximizing or suppressing arousal. Sober and intoxicated men were equally effective at responding in ways consistent with the instructional demands in that they showed more arousal and reported more arousal in the maximize than suppress condition. Therefore, at the explicit or attended task of maximizing versus suppressing arousal magnitude, intoxicated men seemed as effective as sober men.

Second, consistent with our hypothesis about response latencies, sober men showed faster response onset and were faster at reaching their peak session response in the maximize than in the suppress condition, but intoxicated men did not differ based on instructional set. It is important to note that the instructional sets made no explicit mention of response speed. However, it is intuitive that men trying to suppress tumescence would be expected to be slower at evincing any arousal than counterparts trying to maximize tumescence. Presumably suppressers would be restraining their response by cognitively managing their internal experience, such that any erectile response to the erotic stimuli would seem forestalled, comparatively speaking. Indeed, this was the case with sober men. However, this distinction did not occur with intoxicated men.

These two patterns together depict an interesting and somewhat unexpected juxtaposition. At the explicit task of maximizing or suppressing arousal magnitude, intoxicated men seemed as effective as sober men. However, they seemed less effective than sober men at managing the implicit or unattended task of forestalling their genital response to the erotic stimuli. This coincides with other indications that attentional processes generally (Morlet et al., 1990; Wilson et al., 1985) and explicit versus implicit processes specifically are important to elucidating alcohol's effects on erectile responding.

In Study 2, we achieved more differentiated instructional sets than in Study 1. The main effect we obtained is consistent with previous work showing that, despite initial speculations of limited conscious control over autonomically innervated erectile structures (e.g. Hatch, 1981), men can exert control over erectile responding (Adams et al., 1992; Golde, Strassberg & Turner, 2000; Henson & Rubin, 1971; Mahoney & Strassberg, 1991; McAnulty & Adams, 1991). Sex researchers have suggested that men achieve control by focusing attention on arousal-enhancing or arousal-suppressing stimuli (e.g. Hatch, 1981) and by mentally elaborating upon it (Barlow, 1986). According to Barlow's etiological model of sexual dysfunction, sexually functional "men focus on and process erotic cues without difficulty" (Barlow, 1986).

## General Discussion

The most striking outcome of this work is that, contrary to both the conventional wisdom and established science, relatively high dosages of alcohol had limited impact on men's erectile responding. The lowest dosage is widely recognized as substantially intoxicating in that it is the legal criterion for drunk driving and it is widely associated with generalized impairment. At the highest dosage, an alcohol attenuation effect did emerge, but it was confined to one of five measures. Specifically, alcohol reduced peak circumference change, but it did not affect average circumference change, latency to change onset, latency to peak change, or self-reported arousal. This circumscribed effect, when considered in the context of previous null effects at comparably high dosages with wakeful (Langevin et al., 1985) and sleeping (Morlet et al., 1990) men, poses a challenge for the long held view that acute heavy drinking diminishes erectile performance. These data suggest that alcohol's attenuating effects necessitate higher BAC levels to manifest and are more topographically specific than previously thought – affecting only peak response.

Furthermore, alcohol's attenuating effects on erectile functioning may be more context dependent than previously acknowledged. A contextual factor that emerged as influential for response latency indices was the instructional demand to maximize versus suppress arousal. Future research could explore this further by evaluating the specific instructions to forestall response latency and by considering the role of explicit versus implicit instructional demand. Another contextual factor suggested here was level of arousal. Generally, our Ps found the stimulus materials very arousing. Conceivably, highly arousing stimulus conditions provide a context mitigating alcohol attenuation effects. Further work incorporating variable levels of erotic stimulus strength could clarify this possibility. Finally, we evaluated effects on the ascending BAC limb; future work is needed to evaluate the descending limb context.

## Strengths and Limitations

A particular strength of this study is that we addressed methodological concerns identified previously and thereby avoided the impact of several potential validity threats. Limitations include the lack of an alcohol expectancy (placebo) condition, the moderate level drinking status and young age of the sample, and the prospect of volunteer bias. Previous work has shown that expectancy set (the belief that one has been drinking) enhances men's self-reported and physiological arousal independent of low-dosage intoxication (Wilson & Lawson, 1976). Because of the difficulty of convincing placebo participants that they have received a high dose of alcohol, and because our specific interest was in high dosage effects, we did not evaluate alcohol expectancy set or individual differences in *a priori* alcohol expectancies. At high dosages, physiological effects were expected to override any expectancy effects. Given the high BAC levels and the direction of the effects, it is unlikely that expectancies accounted for our findings. Second, age influences erectile functioning, rendering younger men less affected by alcohol attenuation than older men. Third, volunteers for sexual psychophysiological studies tend to have more sexual experience and liberal sexual attitudes than non-volunteers (Strassberg & Lowe, 1995). This tendency constrains generalizability; therefore our findings should be interpreted accordingly.

## Conclusions

In sum, high-dosage alcohol had confined and generally modest effects on erectile responding in a sample of relatively young moderate drinkers. This is not consistent with previous conclusions depicting robust high-dose attenuation effects (Crowe & George, 1989; Wilson, 1977). Absence of attenuation effects in conjunction with alcohol's tendency to heighten sexual risk-taking is, however, consistent with alcohol's persistent association with men's increased sexual activity. Certainly, there is little basis here to view alcohol as

necessarily interfering with sexual response, for sexually functional men. This may shed some light on the longstanding paradox, – “it provokes the desire, but it takes away the performance” – in that, alcohol’s attenuating effects may have been overestimated previously. It may be that Shakespeare’s maxim reliably holds true only at the higher degrees of intoxication, much higher than .10%, which – while relatively rare in laboratory experimentation – may be common in men’s real life encounters.

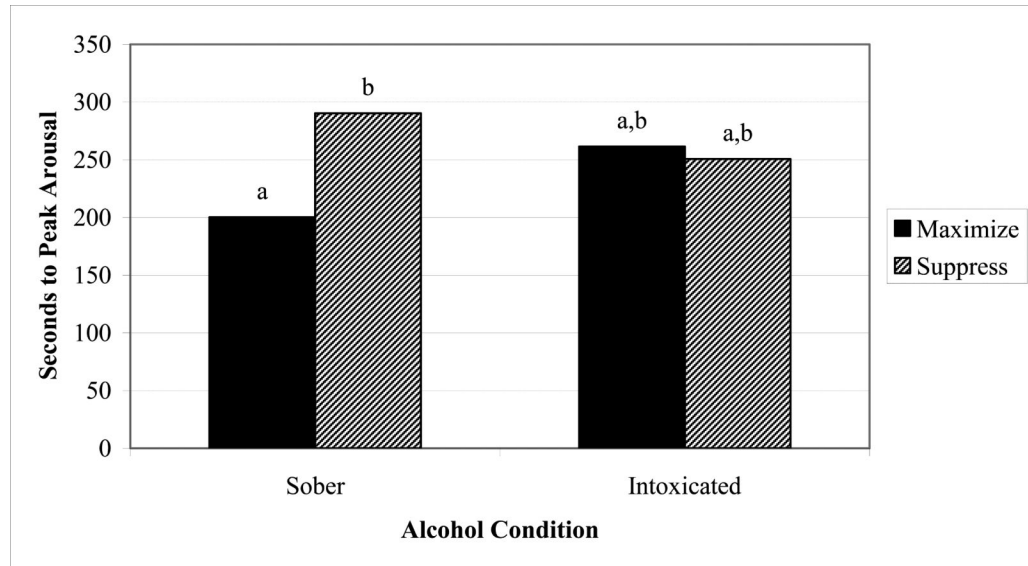
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**Figure 1.** Latency to arousal onset as a function of level of participant's drinking and instructional set in Study 2.



**Figure 2.** Latency to peak arousal as a function of level of participant's drinking and instructional set in Study 2.



**Table 1**  
Means, SDs, and Effect Sizes for Penile Plethysmography and Self-reported Sexual Arousal Measures for Study 1

	Arousal Instructional Set		Alcohol Condition		<i>d</i>
	Maximize	No Instruction	Control	Alcohol (.10%)	
Peak Percentage Circumference Change (mm)	32.80 (13.49)	30.55 (13.54)	34.92 (12.73)	28.30 (13.56) *	.50
Mean Percentage Circumference Change (mm)	23.56 (11.51)	20.19 (11.57)	23.85 (11.10)	19.79 (11.87)	.35
Latency to Arousal Onset (in seconds)	62.90 (68.24)	72.34 (93.69)	54.22 (45.01)	81.61 (106.23)	.34
Latency to Peak Arousal (in seconds)	232.50 (108.75)	212.88 (120.91)	229.70 (111.51)	215.16 (119.05)	.13
Self-reported Sexual Arousal	5.45 (1.11)	4.75 (1.27) *	5.10 (1.31)	5.09 (1.18)	.01

Note:

*d* refers to effect size.

\*  $p < .05$

**Table 2**  
Means, SDs, and Effect Sizes for Penile Plethysmography and Self-reported Sexual Arousal Measures for Study 2

	Arousal Instructional Set		Alcohol Condition		<i>d</i>
	Maximize	Suppress	Control	Alcohol (.08%)	
Peak Percentage Circumference Change (mm)	36.24 (15.16)	26.45 (14.61)*	33.04 (15.52)	29.76 (15.73)	.21
Mean Percentage Circumference Change (mm)	24.02 (12.98)	15.26 (11.49)**	20.92 (12.34)	18.49 (13.73)	.19
Latency to Arousal Onset (in seconds)	67.33 (72.67)	90.54 (75.32)	75.48 (76.42)	82.04 (72.92)	.09
Latency to Peak Arousal (in seconds)	229.84 (108.21)	272.59 (108.16)	245.31 (117.62)	256.43 (101.02)	.10
Self-reported Sexual Arousal	4.82 (1.36)	4.15 (1.57)~	4.74 (1.42)	4.21 (1.54)	.36

Note:

*d* refers to effect size.

\*\*  $p < .01$

\*  $p < .05$

~  $p < .07$