Published in final edited form as:
Addict Behav. 2010 August ; 35(8): 786–790. doi:10.1016/j.addbeh.2010.03.017.

Psychophysiological Reactivity to Emotional Picture Cues Two Years after College Students Were Mandated for Alcohol Interventions

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Abstract

This study examined alcohol use behaviors as well as physiological, personality, and motivational measures of arousal in students approximately 2 years after they were mandated to a brief intervention program for violating university policies about on-campus substance use. Students were categorized into serious (medical referrals, n=13) or minor (residence advisor referrals, n = 30) infraction groups based on the nature of the incident that led to their being mandated. Self-report measures of arousal, sensation seeking, reasons for drinking, and past 30-day alcohol use were completed. Physiological arousal during exposure to emotional picture cues was assessed by indices of heart rate variability. The minor infraction group reported significantly escalating alcohol use patterns over time and a pattern of less regulated psychophysiological reactivity to external stimuli compared to the serious infraction group. The serious infraction group was higher in sensation seeking and there was some evidence of greater disparity between their physiological and self-reported experiences of emotional arousal in response to picture cues than in the minor group. Thus, the two infraction groups represent different subsets of mandated students, both of whom may be at some risk for using alcohol maladaptively. The findings suggest that intervention strategies that address self-regulation may be beneficial for mandated college students.

Keywords

emotional reactivity; affective cue; self-reported arousal; heart rate variability; psychophysiology; college students

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Contributors

Jennifer Buckman performed the statistical analyses and wrote the first draft of the manuscript. Helene White is the principal investigator of the parent studies from which the present sample was recruited and responsible for the analytic design. Marsha Bates is the principal investigator of the study that provided the majority of data used in the analyses; she contributed to the selection of variables and the interpretation of the results. Both Drs. White and Bates participated in writing subsequent drafts of the paper and approved the final manuscript.

Conflict of Interest

None of the authors of this manuscript have any actual or potential conflict of interest.

1. Introduction

Risky alcohol use behaviors are common in the college setting, with almost 70% of U.S. college drinkers reporting heavy drinking in the past 2 weeks (O'Malley & Johnston, 2002). A small fraction of these heavy drinking college students find themselves involved in incidents that result in mandatory substance use interventions (Barnett & Read, 2005). Like students in Greek organizations (Wechsler, Kuh, & Davenport, 1996) and student athletes (Yusko, Buckman, White, & Pandina, 2008), mandated students appear to represent a subpopulation within the college setting that is at heightened risk for the development of alcohol use disorders (Barnett & Read, 2005). Yet gauging the actual level of risk for future problematic substance use behaviors among this heterogeneous pool of college students represents a formidable challenge, especially considering the range in seriousness of the precipitating alcohol-related events leading to the mandated intervention.

The majority of studies on mandated students have focused on the efficacy of the intervention programs aimed at interrupting the trajectory of problematic substance use behaviors among these individuals (e.g., Barnett, Murphy, Colby, & Monti, 2007; Borsari & Carey, 2005; Fromme & Corbin, 2004; White et al., 2006; White, Mun, & Morgan, 2008; White, Mun, Pugh, & Morgan, 2007). Data on the long-term drinking patterns of mandated students and other individual difference factors that may place them at risk for using alcohol in a problematic, potentially life-threatening manner are lacking. To address these questions, the present study assessed alcohol use behaviors as well as physiological, personality, and motivational measures of arousal modulation in a sample of university students approximately 2 years after they were mandated to an intervention program for violating university policies about on-campus substance use. Frequency and quantity of alcohol use, sensation seeking, reasons for drinking, and self-reports of arousal and cardiovascular reactivity to emotional picture cues were compared between students who were mandated following a serious substance use infraction (e.g., alcohol poisoning) and those mandated following a relatively minor infraction (e.g., drinking in a dormitory room). The aim was to explore underlying, potentially persistent sources of risk beyond the standard measures of alcohol use (e.g., quantity or frequency of use), which alone may not sufficiently distinguish those students who are at greatest risk for using alcohol in a hazardous manner (Morgan, White, & Mun, 2008).

A common motivation for alcohol and drug use at all ages is the desire to enhance or change one's emotional state (Cooper, Frone, Russell, & Mudar, 1995; Labouvie & Bates, 2002). The inability to modulate emotional arousal on the psychological and physiological level further has been linked to the failure to self-regulate substance use (Koob & Le Moal, 2001). In the present study, individual differences in the regulation of physiological arousal was assessed by characterizing the cardiovascular system's ability to respond flexibly and rapidly to internal and external stimuli. Mean heart rate is a commonly used psychophysiological measure of reactivity, however, changes in the time interval between heart beats, known as heart rate variability (HRV), is a more powerful measure of adaptive cardiovascular regulation (Porges, 2007). Thus, in addition to heart rate, two indices of HRV were employed. A 0.1 Hz HRV index (Vaschillo et al., 2008) was used to gauge the strength and speed of the reflexes that maintain optimal cardiovascular functioning via blood pressure control, which reflects an individual's capacity to modulate responses to changes in their internal and external environments (Vaschillo et al., 2008; Vaschillo, Vaschillo, Buckman, Bates, & Pandina, 2010). An index of high frequency HRV was also used to measure inhibitory processes that modulate cardiovascular activity through the vagus nerve (Benarroch, 1997). These variability measures reflect flexibility within the cardiovascular system and, when considered together, offer insight into individual differences in the ability to regulate cardiovascular function to optimize behavioral flexibility. Moreover, the 0.1 Hz HRV index responds sensitively to the

emotional valence of visual cues (Vaschillo et al., 2008) suggesting its utility in characterizing the dynamic range of an individual's ability to regulate negative affect and emotional arousal.

In general, lower heart rate and greater HRV in the resting state reflect better health (e.g., Giardino et al., 2000; Lehrer et al., 2003). Less is known about optimal changes in HRV in response to emotional stimuli, especially as they relate to alcohol use behaviors. A previous study found that individuals categorized as high risk based on their resting state cardiovascular function, alcohol use levels and emotional suppression and disinhibition reasons for drinking showed greater 0.1 Hz HRV reactivity to emotional, alcohol, and drug-related picture cues compared to a normative risk group (Mun et al., 2008). This suggests that a relatively higher level of emotional reactivity may be a sign of physiological dysregulation that in turn portends greater risk for future problematic alcohol and drug use.

The experience of serious negative consequences from alcohol use is a feature that distinguishes social drinking from alcohol-related disorders (American Psychological Association, 2000) and, at face value, drinking episodes that result in major medical or legal consequences would seem to signal the greatest predictive liability or risk severity. Thus, we expected that students mandated following a serious incident would exhibit greater arousal dysregulation, as indicated by greater 0.1 Hz HRV reactivity to picture cues, compared to those mandated following a minor incident. Because suppression of high frequency HRV is indicative of autonomic nervous system activation, we expected less high frequency HRV reactivity (i.e., less change from baseline) in the serious compared to minor infraction group. In addition, the serious infraction group was expected to exhibit to higher levels of sensation seeking (e.g., Cooper, Frone, Russell, & Mudar, 1995; Johnson & White, 1989; Zakletskaia, Mundt, Balousek, Wilson, & Fleming, 2009), greater use of alcohol to suppress negative emotions (Labouvie & Bates, 2002), and more self-reported arousal (Bobadilla & Taylor, 2007). These hypotheses, however, are tempered by recent evidence that students involved in a serious, compared to a minor, incident may typically drink more moderately (Barnett et al., 2008), reduce their drinking more immediately following the incident (Morgan et al., 2008) and respond better to an intervention (Mun, White, & Morgan, 2009).

2. Method

2.1 Participants and Procedures

This study included 43 university students (51% female; 67% Caucasian, 30% Asian, and 3% other or mixed) who volunteered to participate in a laboratory experiment approximately 2 years (mean = 706.2 days, SD = 235.4) after they were mandated to an intervention because they violated university policies about on-campus substance use. At the time of the violation, most participants were first-year students (95%) and referred for alcohol-related (95%), rather than drug-related, violations. At the time of the experiment, participants averaged 20.2 years of age (SD = 1.0). Participants were categorized based on the seriousness of the referring violation: the minor infraction group (n = 30, 70%) included those individuals who were referred by residence hall advisors for being present in a dormitory room where drinking was taking place; the serious infraction group (n = 13, 30%) included those individuals whose referral involved emergency medical service or hospital personnel.

This sample represents a subset of a large mandated sample that was originally assessed for two intervention studies described in more detail by White and colleagues (Morgan et al., 2008; White et al., 2006; White et al., 2008; White et al., 2007)[1]. Self-report data were collected

[1]Recruitment for this study was indirectly related to the parent studies and accomplished via emails from the clinical staff involved in the original interventions. The investigators in this study did not have access to information about who was successfully contacted and who declined to participate in this study.

during the pre-intervention assessment, which was part of White et al.'s original studies, as well as during the current study's 4-hour laboratory session, which occurred approximately 2 years later. Physiological data were collected during the laboratory session only. The experiment, in which each participant was individually tested, included a baseline assessment, a picture cue exposure study, and a memory study; only data related to the baseline assessment and picture cue study were used in the present analyses. This study was approved by the university Institutional Review Board for the Protection of Human Subjects Involved in Research. All participants provided written informed consent and were compensated $50 for their time.

2.2 Measures

2.2.1. Self-report Data—Alcohol use behaviors in the 30 days prior to the intervention assessment and in the 30 days prior to the laboratory session were measured as typical number of drinks consumed in a day/occasion (quantity), typical number of drinking days per week (frequency), and largest number of drinks consumed in a day/occasion (largest quantity) (Pandina, Labouvie, & White, 1984). During the laboratory session, sensation seeking was assessed from three subscales (thrill and adventure seeking: alpha = .87, experience seeking: alpha = .75, disinhibition: alpha = .65) of the Sensation Seeking scale (Zuckerman, 1994), and motivations for use were calculated from the three subscales (social: alpha = .64, disinhibition: alpha = .85, and suppression: alpha = .88) of the Reasons for Drinking questionnaire (Labouvie & Bates, 2002).

2.2.2. Physiological Assessment—Participants were seated in a comfortable chair in front of a TV screen in a sound-attenuated, dimly lit room. Physiological sensors were attached to their arms and legs. A standardized low-demand baseline task (Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992) was completed to equate cognitive load across participants. Participants then viewed blocks of pictures that varied in emotional valence (Lang, Bradley, & Cuthbert, 1999) and alcohol- and drug-related picture cues (Stritzke, Breiner, Curtin, & Lang, 2004; Tapert et al., 2003; with additional stimuli developed in our lab). Each picture cue block of a given type (negative emotional, positive emotional, neutral, alcohol-related, marijuana-related, cocaine and club drug-related) included a set of 15 pictures, which was presented twice per block. Presentation order of pictures within sets was randomized. Presentation order of picture cue blocks was counterbalanced across participants. Cues were presented at a frequency of 0.1 Hz (5 seconds (s) on/5 s off) with a 30 s inter-block interval. During the 5-second interstimulus (off) interval, participants used a standardized 9-point Likert scale (Self-Assessment Manikin; Lang et al., 2001) to rate their arousal from the pictures.

During the baseline and picture cue tasks, electrocardiogram (ECG) recordings were continuously collected (1,000 samples per second) using a Powerlab Acquisition System (ADInstruments, Colorado Springs, CO). Beat-to-beat intervals of the ECG were analyzed using WinCPRS software program (Absolute Alien Oy, Finland). Heart rate (HR, Task Force, 1996), high frequency HRV (Cooke et al., 1999; Taylor, Carr, Myers, & Eckberg, 1998), and 0.1 Hz HRV (Vaschillo et al., 2008) indices were calculated.

2.2.3. Analyses—To correct for skew, frequency of drinking (in the 30 days prior to the pre-intervention and 30 days prior to the laboratory assessment), as well as high frequency and 0.1 Hz HRV data, were log transformed. HR and HRV measures are presented as change scores representing the average reactivity to each picture cue blocks minus the average activation during the low cognitive demand baseline task. Regression analyses were used to compare psychosocial, psychophysiological, and alcohol use factors in the serious and minor infraction groups using MPlus (Muthén & Muthén, 1998–2007). Paired t-tests were performed to examine changes in drinking from pre-intervention to the time of the experiment using SAS (SAS

Institute Inc., Cary, NC). There was a larger percent of females in the serious (85%) versus minor (37%) infraction group (Fisher's Exact Test, $p < .01$), and a non-significantly larger percent of non-white individuals in the serious (46%) versus minor (27%) infraction group. Based on these group differences and their possible influence on drinking behaviors (Wallace et al., 2003), gender and race/ethnicity were included as covariates in all analyses. In addition to statistical significance testing, effect size (ES) measurements were considered because they are less sensitive to sample size and issues related to multiple testing. ES was calculated as mean differences between the groups divided by the standard deviation. ES differences of 0.2 – 0.5 were considered small, 0.5 – 0.8 were considered medium, and 0.8 or greater were considered large; ES below 0.2 were considered negligible (Cohen, 1988).

Results

As shown in Table 1, differences between the infraction groups in past 30-day alcohol use prior to the substance use violation and 2 years later did not reach statistical significance. Changes in drinking from pre-intervention to the time of the experiment, however, revealed significant increases over the 2 years in quantity of alcohol consumed per occasion ($t(28)=2.43$, $p < .05$), the frequency of alcohol use ($t(28)=3.34$, $p < .01$), and the largest quantity of alcohol consumed ($t(28)=2.10$, $p < .05$) within the minor infraction group, but not the serious infraction group ($t(12)=1.84$, *n.s.*; $t(12)=1.40$, *n.s.*; $t(12)=-0.20$, *n.s.*, respectively).

During the low cognitive-demand baseline task, the two groups did not differ significantly in HR or high frequency HRV, however the 0.1 Hz HRV index was significantly higher in the serious versus minor infraction group (β: 0.30, $p < .05$). Independent of this baseline difference, the serious infraction group showed significantly less 0.1Hz HRV reactivity (β: − 0.42, $p < .01$) to neutral picture cues than did the minor infraction group. The serious infraction group also showed significantly less 0.1Hz HRV reactivity (β: −0.40, $p < .01$) to positively-valenced picture cues compared to the minor infraction group. A parallel trend (β: −0.32, $p = .051$) was noted in the 0.1 Hz HRV index reactivity to negative emotional cues between the groups (Table 1). In terms of high frequency HRV reactivity, the serious infraction group showed greater reduction in response to positive stimuli compared to the minor infraction group (β: −0.33, $p < .05$).

The serious infraction group, compared to the minor infraction group, rated the neutral picture cues as more arousing (β: 0.35, $p < .05$) (Table 1). Self-reported arousal to negative and positive cues did not vary significantly across groups. Considering together physiological and self-reported differences in arousal between the two groups, there was a dissociation between physiological and self-reported arousal in response to neutral cues wherein the serious group exhibited significantly less 0.1 Hz HRV reactivity but reported significantly higher levels of arousal than the minor group. Further, in response to positive emotional cues, the groups differed significantly in physiological arousal with the serious group again showing lower 0.1 Hz HRV reactivity, while self-reporting arousal at a level equivalent to the minor group. This pattern of results suggests a greater divergence between physiological and self-reported arousal levels in the serious, compared to minor, infraction group.

Compared to the minor infraction group, the serious infraction group reported higher sensation seeking needs on the experience seeking (β: 0.35, $p < .05$) and thrill/adventure seeking (β:0.43, $p < .01$) subscales (Table 1). There were no group differences in disinhibition, emotional suppression, and social enhancement reasons for drinking (Table 1).

Discussion

The present study offers preliminary evidence that physiological and psychological constructs beyond the standard measures of alcohol use may be useful in understanding the nature of risk for future alcohol use problems. Contrary to the hypotheses, students mandated following minor alcohol use infractions exhibited the more predictable pattern of risk: a trajectory of escalating alcohol use over time and less modulation of psychophysiological reactivity to external stimuli. The serious infraction group displayed a different constellation of risk factors including heightened sensation seeking tendencies and evidence of discrepancies between their self-reported arousal and their cardiovascular-mediated reactions, yet average alcohol use behaviors, which had not increased over a two-year period.

In the present sample, college students' drinking behaviors after getting caught for violating substance use policy, but prior to involvement in an alcohol use intervention program, did not significantly differ between students mandated following a serious infraction and those referred for a minor incident. This is consistent with earlier results from the larger mandated student sample (Morgan et al., 2008) that showed that standard alcohol quantity and frequency measures did not distinguish those students who had used alcohol in a potentially life-threatening manner at the time of the intervention. Two years later, students who had been mandated for a substance use violation of minor consequence reported alcohol use patterns that were higher in trend and that had significantly increased over time, compared to the use patterns of the serious infraction group. Effect size calculations suggested that the minor infraction group was more likely to engage in heavy episodic drinking than the serious infraction group 2 years later.

Furthermore, compared to the serious infraction group, the minor infraction group showed evidence of poorer arousal modulation in response to both neutral and emotionally valenced stimulus cues. Physiological arousal was assessed using 0.1 Hz and high frequency HRV indices, which capture different aspects of cardiovascular responding. The 0.1 Hz HRV index gauges the capacity of the system to react to perturbations in blood pressure (i.e., the baroreflex) that are caused by internal and external cues (Vaschillo et al., 2008). While higher basal 0.1 Hz HRV is considered healthful, greater 0.1 Hz HRV in response to emotionally arousing pictures may indicate reduced or less effectual modulation of physiological arousal (Mun et al., 2008). The high frequency HRV index, on the other hand, reflects the inhibitory processes that control arousal. During mental or physical exertion, high frequency HRV decreases to allow activation of autonomic and central nervous system processes (Benarroch, 1997). The finding of less suppression of high frequency HRV while viewing positive picture cues may suggest that individuals in the minor infraction group are not "activated" by positive stimuli to the same degree as those in the serious infraction group. Further research is needed to replicate this finding and clarify this interpretation. Nonetheless, the profile of HRV reactivity demonstrated by the minor infraction group may signal some degree of autonomic nervous system dysregulation relative to the serious infraction group.

In contrast, as hypothesized, students who were involved in infractions serious enough to require medical intervention demonstrated a personality indicator of risky arousal modulation as reflected by their higher levels of sensation seeking. They also showed a dissociation between consciously perceived arousal as reflected in their self-reported ratings of the arousal value of stimulus cues and their physiological reactivity to the cues, relative to the minor group. For example, the serious infraction group demonstrated modest 0.1 Hz HRV reactivity to neutral pictures, but rated these pictures as more arousing than did the minor infraction group. Unlike self-report assessments that require conscious awareness of one's internal state and underlying cognitive strategies, physiological processes often operate outside of conscious awareness yet nonetheless influence behaviors through their impact on the excitation-inhibition

balance of the cortex (e.g., Thayer & Brosschot, 2005). Thus, 2 years after the referral, the serious infraction group showed evidence of dissociation between their volitional ratings of arousal and the physiological processes that help modulate their arousal state. Moreover, they demonstrated higher risk personality characteristics, including significantly greater sensation seeking and non-significant, but moderate effect size, elevations in emotional suppression reasons for drinking. These factors may portend persistent risk for future alcohol-related events, even though this infraction group's general pattern of alcohol consumption had remained relatively stable and did not significantly increase as did their minor infraction peers' alcohol consumption.

The type of alcohol use violations that led to the mandated intervention differed dramatically in the minor and serious infraction groups. Although, taken at face value, it would seem that those students involved in more serious and life-threatening alcohol use violations would be at greater risk for future problematic alcohol use, this assumption was not supported by the results. Instead, the data suggest that this group of mandated students may be less able to identify their state of physiological arousal, but more likely to seek greater stimulation to feel aroused. This may translate into a failure to correctly assess the risk of potentially serious alcohol-use consequences (i.e., properly gauge their limits), which, in combination with higher sensation seeking traits, may increase risk for engaging in a discrete episode of dangerous alcohol use (also see Barnett et al., 2008).

Although gender and race/ethnicity were statistically controlled in the present analyses, it is of note that the minor infraction group was comprised predominantly of Caucasian, non-Hispanic males, a subset of students typically associated with high-risk drinking in the college setting (O'Malley & Johnston, 2002). The serious infraction group in this study, on the other hand, was disproportionally female. Female college students tend to consume alcohol less frequently and in lower quantities than male college students (e.g., O'Malley & Johnston, 2002). Thus, future studies of sufficient size are needed to allow for gender-specific comparisons. In addition, confirmation with a larger sample of mandated students who are recruited directly following the infraction and whose physiological reactivity can be assessed before, as well as after, the intervention is warranted. Given that the participants in the present study represent only a small subset of the overall mandated student population, the generalizability of the present results is not clear. Nonetheless, the present study contributes to the current literature on mandated students by suggesting a potential role of physiological, as well as psychosocial and alcohol use, factors in contributing to different kinds of risk for future problematic alcohol use behaviors. The results suggest that interventions for college students that focus primarily on alcohol use behavior modification may be limited; students, regardless of violation severity, may benefit from strategies that enhance psychological and physiological self-regulation skills.

Acknowledgments

Role of Funding Sources

This study was supported in part by the National Institute of Drug Abuse (DA17552) as part of the Rutgers Transdisciplinary Prevention Research Center and the National Institute of Alcohol Abuse and Alcoholism (K02 AA00325). Neither NIDA nor NIAAA had a role in the study design, collection, analysis or interpretation of the data, manuscript preparation or submission. Also supported by NIH grants K01AA017473 and R01AA016798.

The authors would like to thank Evgeny and Bronya Vaschillo for analysis of the psychophysiological data; Tomoko Udo, Adam Thacker, and Thomas Morgan for their assistance with data collection and data base management, and the staff of the student assistance program (Lisa Laitman, Barbara Kachur, and Brian Kaye) for their assistance with recruitment. An earlier version of this paper was presented at the 32nd Annual Scientific Meeting of the Research Society on Alcoholism, Washington D.C., July 2008.

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Table 1

Differences[a] in the substance use profiles as well as in physiological, personality, and motivational measures of arousal between students mandated following a minor or serious substance use-related incident

	Minor Infractions	Serious Infractions	Effect Size[b]
Substance Use in 30 days prior to mandated invention program			
Quantity [c]	3.48 (2.76)	2.81 (3.20)	−.24 S
Frequency [d]	0.54 (0.34)	0.52 (0.49)	−.05
Largest Quantity [e]	5.83 (4.37)	5.31 (4.08)	−.12
Substance Use in 30 days prior to experiment (approximately 2 years post-intervention)			
Quantity [c]	5.10 (3.38)	3.77 (2.58)	−.39 S
Frequency [d]	0.81 (0.38)	0.76 (0.56)	−.15
Largest Quantity [e]	7.80 (4.52)	5.15 (3.72)	−.59 M
Reactivity to Neutral Picture Cues			
0.1Hz HRV [f, g]	1.44 (1.27)	0.70 (1.17)*	−.59 M
High Frequency HRV [f, g]	−0.24 (0.50)	−0.25 (0.38)	−.02
Heart Rate [g]	1.82 (2.73)	2.28 (2.42)	.17
Arousal Rating [h]	2.46 (0.98)	3.20 (0.92)*	.76 M
Reactivity to Positive Picture Cues			
0.1Hz HRV [f, g]	1.49 (1.25)	0.49 (0.90)*	−.80 L
High Frequency HRV [f, g]	−0.11 (0.50)	−0.39 (0.48)*	−.55 M
Heart Rate [g]	1.36 (3.54)	1.76 (2.69)	.11
Arousal Rating [h]	4.68 (1.30)	4.83 (1.21)	.11
Reactivity to Negative Picture Cues			
0.1Hz HRV [f, g]	1.82 (1.30)	1.15 (0.94)	−.51 M
High Frequency HRV [f, g]	−0.17 (0.41)	−0.20 (0.61)	−.06
Heart Rate [g]	0.95 (2.63)	0.61 (2.89)	−.13
Arousal Rating [h]	6.29 (1.19)	6.68 (1.09)	.33 S
Sensation Seeking			
Experience seeking (range 0 – 10)	4.97 (2.29)	6.15 (1.29)*	.52 M
Thrill/adventure seeking (range 0 – 10)	6.23 (3.06)	8.31 (2.23)*	.68 M
Disinhibition (range 0 – 10)	4.90 (2.17)	5.31 (1.54)	.19
Reasons for Drinking			
Social Facilitation (range 0 – 16)	7.60 (1.80)	6.54 (1.99)	−.59 M
Disinhibition (range 0 – 16)	2.73 (2.26)	1.77 (2.45)	−.43 M
Suppression (range 0 – 26)	3.03 (2.63)	4.46 (4.65)	.54 M

[a] presented as unadjusted means (SD). Statistical comparisons were made using gender and race as covariates, effect sizes were calculated from unadjusted means;

[b] effect sizes were measured as the difference in means divided by the SD of the minor infraction group. S = small, M = medium, L = large;

[c] typical number of drinks in a day,

[d] represented as log-transformed frequency of drinking per week (e.g., 0.5 = 1–2 times per week, 0.75 = 2–3 times per week);

[e] largest number of drinks consumed in a day;

[f] log transformed;

[g] represented as the change from baseline;

[h] rated on a 9-point Likert scale.

HRV = heart rate variability;

* $p < .05$