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Frontal alpha asymmetry in alcohol-related intimate partner violence

Brandi C. Fink,[1] Breannan C. Howell,[2] Sarah Salway,[1] James F. Cavanagh,[2] Derek A. Hamilton,[2] Eric D. Claus,[3] and Madeline E. Frost[1]

[1]Department of Psychiatry and Behavioral Sciences, The University of New Mexico, Albuquerque, NM 87131, USA, [2]Department of Psychology, The University of New Mexico, Albuquerque, NM 87131, USA, and [3]Mind Research Network, Albuquerque, NM, USA

Correspondence should be addressed to Brandi C. Fink, Department of Psychiatry and Behavioral Sciences, 1 University of New Mexico, MSC09 5030, Albuquerque, NM 87131, USA. E-mail: bcfink@salud.unm.edu.

Abstract

Abstract Electroencephalographic (EEG) frontal alpha asymmetry (FAA) has been associated with differences in the experience and expression of emotion, motivation and anger in normal and clinical populations. The current study is the first to investigate FAA in alcohol-related intimate partner violence. EEG was recorded from 23 distressed violent (DV) and 15 distressed nonviolent (DNV) partners during a placebo-controlled alcohol administration and emotion-regulation study. The State-Trait Anger Expression Inventory 2 was used to evaluate anger experiences and was collected from both participants and their partners. During baseline, acute alcohol intoxication DV partners had significantly greater right FAA, whereas DNV partners showed greater left FAA. Both partner types demonstrated significantly greater right FAA during the placebo beverage condition of the emotion-regulation task when viewing evocative partner displays of contempt, belligerence, criticism, defensiveness and stonewalling, but greater left FAA during acute alcohol intoxication. Although no group differences were found in the emotion-regulation task, partner self-reported anger experiences accounted for 67% of the variance in the FAA of DV participants when intoxicated and viewing evocative stimuli, suggesting dyadic processes are important in understanding alcohol-related IPV. These findings suggest that FAA could index the affective and motivational determinants through which alcohol is related to IPV.

Key words: frontal alpha asymmetry; alcohol; intimate partner violence; couple conflict; emotion

Introduction

Intimate partner violence (IPV) is a significant public health problem that exacts a toll on medical and mental health care, social services and criminal justice systems. IPV is estimated to cost the United States $8.3 billion dollars annually (Max *et al.*, 2004). It is also more common than most realize, with national surveys and a range of other samples estimating that 30–50% of couples will experience physical aggression at some point in their relationship (Straus and Gelles, 1986; Lawrence and Bradbury, 2001; Slep and O'Leary, 2005), and up to 35% will experience IPV in any given year (Rhoades *et al.*, 2010). Furthermore, while IPV toward females may appear on the surface to be more prevalent than towards males, this is likely due to a reporting bias rather than any real difference in the gender of the aggressor. In fact, meta-analytic studies of gender differences in aggressive behavior found that there are no gender differences in aggressive behavior when males and females are in emotionally aroused states (Knight *et al.*, 2002). This finding is consistent with the IPV literature of over 200 studies showing gender symmetry in IPV (Straus, 2006). There are also no gender differences among adults in the use of physical aggression once emotional

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arousal is present (Knight *et al.,* 2002), nor are there gender differences in aggression under conditions of high provocation (Giancola, 2004). It is important to note that the IPV described here represents family-only violence, and eschews the partner violence of anti-social, more generally violent individuals.

Compounding the problem of physical aggression between partners is the use of alcohol. Alcohol use is present in most instances of IPV (57–70% of IPV incidents), and during conflict, instances of physical aggression are more likely to occur than verbal aggression if one or both partners have used alcohol (Leonard and Quigley, 1999). More severe IPV incidents also occur during heavier drinking episodes (e.g. binge drinking; El-Bassel *et al.,* 2004; Foran and O'Leary, 2008; Graham *et al.,* 2011; Kantor and Straus, 1989; Pan *et al.,* 1994; Testa and Leonard, 2001). Not only does alcohol use lead to more severe violent episodes, it also leads to more mutually violent ones (Testa *et al.,* 2003). Furthermore, drinking alcohol within 3 h of an argument with a partner is a strong predictor of female IPV (Shook *et al.,* 2000), and there are no gender differences in aggressive tendencies once males and females are drinking (Stappenbeck and Fromme, 2013).

Despite the widespread financial, mental health and physical consequences of IPV, psychosocial approaches to understanding the alcohol and IPV association have yielded very little knowledge that has advanced effective treatment for IPV, and currently there are no effective treatments (Babcock *et al.,* 2004; Sartin *et al.,* 2006). Understanding the affective and motivational determinants involved in alcohol-related IPV is the first step in developing rational treatments.

Frontal alpha asymmetry and anger expression

Early investigations of frontal alpha asymmetry (FAA) and emotion posited that left frontal alpha activity were associated with the experience and expression of positive emotions, and that right frontal alpha activity was associated with the experience and expression of negative emotions (Ahern and Schwartz, 1985; Silberman and Weingartner, 1986). Subsequent studies reconceptualized these patterns of alpha asymmetry activity to be associated with approach-related emotions and withdrawal-related emotions, respectively (Davidson, 1995; Harmon-Jones and Allen, 1997). Another view is a combination of the previous two and posits that left frontal asymmetry is associated with the experience and expression of approach-related positive emotions, and right frontal asymmetry is associated with withdrawal-related negative emotions (Davidson, 1998; Tomarken and Keener, 1998). The approaches to understanding FAA have been criticized, however, for confounding emotion and direction of motivation because it has also been found that anger (negative valence) is associated with increased left FAA (Harmon-Jones and Gable, 2018). More specifically, experimental manipulations of anger increased relative left FAA, and the asymmetry witnessed during the anger-evoking situation was related to behavioral aggression (Harmon-Jones, 2004). The authors concluded that anger-inducing situations increase left frontal asymmetry because the associated increases in approach motivation would assist in behavior that may rectify the situation (Harmon-Jones, 2004).

Current study

The current study is the first investigation of FAA in distressed violent (DV) and distressed nonviolent (DNV) partners during a placebo-controlled alcohol administration and emotion-regulation study. Because this is the first study of the pharmacological effects of alcohol on FAA, the first portion of the study was conducted to characterize alcohol effects in DV and DNV partners during the baseline condition. The subsequent portions of the study were conducted to characterize the effects of alcohol and evocative stimuli on FAA in DV and DNV partners. We hypothesized that DV partners would demonstrated greater left FAA when intoxicated and viewing evocative partner stimuli than DNV partners. Last, we attempted to replicate previous research that has found associations between baseline measures of FAA and the State-Trait Anger Expression Inventory-2 (STAXI-2; Spielberger, 1999) subscales of trait anger, anger expression-out, anger expression-in, anger control-out, anger control-in (Hewig *et al.,* 2004).

Method

Participants

Partners in the present study were drawn from a larger study investigating over-arousal as a mechanism between alcohol use and IPV (AA022367). Couples were recruited from the community via radio, television and newspaper advertisements, and eligibility screening occurred at the couple level. Because the current study is a secondary analysis, handedness was not collected. Eligible participants were (1) English speaking, (2) heterosexual, (3) age 21–45-years-old, (4) in a distressed relationship (revised dyadic adjustment scale [DAS] $\leq$ 47), (5) had two binge drinking episodes in the previous 30 days (to qualify for an alcohol-administration study), (6) were married or cohabitating at least 6 months, (7) showed no signs of physical aggression outside of the intimate partner relationship and (8) provided a breath alcohol level of 0.0 g% at all visits. DV partners exhibited at least mild physical aggression (twisted partner's arm or hair) in the previous 6 months, whereas DNV partners exhibited only relationship distress. Participants were excluded if they (1) were currently separated, (2) had an order of protection in place, (3) were facing violence-related criminal charges, (4) were currently in a domestic violence shelter, (5) presented with evidence of psychosis or severe personality disturbance, (6) were pregnant (female participants were pregnancy tested at all experimental sessions), (7) were taking a medication contraindicated for use with alcohol, (8) were currently taking insulin or oral hypoglycemic medication, (9) had an alcohol use disorder identification test score $>$19 and/or indicating alcohol dependence symptoms, (10) reported illicit drug use (except marijuana) and (11) provided a positive urinalysis for opioid or illicit drug use at the stimuli acquisition session.

Participants included in the present analysis were 23 DV partners (12 female, 11 male), and 15 DNV partners (7 female, 9 male). The mean age of the sample was 32 (SD 4.8 years, range 23–40 years). Data from two DV partners were not included in the analyses of the FAA in the emotion-regulation tasks due to movement artifacts during the alcohol condition leaving insufficient data for analysis.

Ethical considerations

The study was approved and overseen by the Human Research Review Committee of the University of New Mexico Health Sciences. There were protections in place both for IPV and for alcohol consumption. Protections for IPV: both partners completed a mood survey at the conclusion of the stimuli acquisition session, and at the conclusion of the experimental session by the participating partner. Participants could not rate feeling worse than 'slightly negative' on a scale ranging from 'very negative' to 'very positive' and be dismissed from the study session. If one or both partners rated feeling worse than 'slightly negative,' they were interviewed by the PI, a licensed clinical psychologist, who used interviewing techniques to de-escalate the partner(s). Each partner was also phoned 24 h after each session, and 1 week after completion of the experimental sessions to ensure that study procedures did not contribute to a violent argument between partners. Each partner was individually provided with referral materials to therapy and legal resources.

Protections for the consumption of alcohol included participants being required to have reported at least two binge drinking episodes in the previous month (>4 drinks for males, >3 drinks for females). Pregnancy testing was completed for all female participants before the placebo and the alcohol conditions. During detoxification, participants were breathalyzed every 15 min and required to remain in the laboratory until two consecutive Breath alcohol concentration (BAC) readings of 0.03% or below were achieved, as recommended by the NIH National Institute on Alcohol Abuse and Alcoholism (NIAAA) guidelines for the safe release of participants (https://www.niaaa.nih.gov/Resources/ResearchResources/job22.htm).

Procedures and materials

The parent study was a counter-balanced placebo-controlled alcohol administration study that consisted of three sessions; an initial stimuli acquisition session that involved both partners, and two experimental sessions that involved only one partner. Data presented here were drawn from the experimental sessions. DV participants were pseudo-randomly selected for participation in the experimental sessions. If gender symmetry in the use of physical aggression was reported by a couple, a partner was randomly selected for participation. If the couple was asymmetrical in their self-reported use of physical aggression, the partner self-reporting the greatest use of physical aggression was invited to participate. DNV participants were matched on sex, relationship distress and age to DV participants and reported only relationship distress and no physical aggression by either partner.

The partners selected for the experimental sessions returned to the laboratory on two separate occasions for a counter-balanced alcohol and placebo electroencephalographic (EEG) data collection sessions. Participants were seated in a chair a comfortable distance from a TV monitor displaying stimuli, prepared for recording and then administered either an alcohol beverage or a placebo beverage. Participants engaged in a 5-min baseline Vanilla Task (Jennings *et al.*, 1992) while the recording of EEG activity was conducted. The Vanilla Task is a minimally demanding color detection task (viewing blocks as they change color and counting number of blue boxes) that has been shown to be superior to a resting baseline task in between- and within-baseline stability, amplitude and significance of responsivity (Jennings *et al.*, 1992).

Alcohol condition protocol. Participants received a mixed drink (cranberry juice and 100-proof vodka) intended to raise their blood alcohol concentration (BAC) to a target dose of 0.08 g% using a standard formula for calibrating alcohol doses to achieve target BACs. Specifically: Alcohol dose (g) = ((10 * BAC * TBW)/0.8) + (10 * MR * (DDP + TPB)) * (TBW/0.8). (BAC = blood alcohol concentration, TBW = total body water, MR = alcohol metabolism rate, DDP = duration of drinking period, TPB = time to peak BAC; Curtain and Fairchild, 2003). Participants were asked to drink the beverage within 9 min to ensure they remained on the ascending limb or reached peak BAC during the experimental task. Baseline recording began when participants reached a BAC of 0.06 g%.

Placebo condition protocol. Procedures were identical to the alcohol condition, except participants consumed a volume of juice equivalent to the volume of beverage consumed in the alcohol condition. To maintain blindness to the condition, the cup was misted with vodka and a small amount (~3 ml) of vodka was floated on top of the cranberry juice to produce the smell and taste of an alcohol beverage.

Electroencephalography recording and processing. EEG data were collected using the BrainVision actiCHamp 64-channel, DC amplifier, 24-bit resolution, biopotential 10–20 system. EEG data were recorded with filters set at 0.01–100 Hz, digitized at a sampling rate of 500 Hz and stored on a computer using PyCorder software. During EEG, recording electrodes were referenced to one channel located on the right mastoid. All data analysis was performed in Matlab using the EEGlab toolbox and plugins.

Preprocessing and analysis of EEG data was modeled using recommendations from Smith *et al.* (2017). Data were referenced offline to the average and bandpass filtered at 1–50 Hz. To identify individual components containing artifacts, the automatic EEG artifact detection based on the joint use of spatial and temporal features (ADJUST; Mognon *et al.*, 2011) algorithm was used. ADJUST is an EEGlab plugin that utilizes properties of time and space to detect eye blink and discontinuity artifact, and has been shown to be more accurate than human raters (Smith *et al.*, 2017). The average time of artifact free data that was used in the analysis was 120.19 s (SD = 17.43; range 76–146 s) for the alcohol beverage condition, and 120.59 s (SD = 13.21; 89–140 s) for the placebo beverage condition. There were no significant differences in time used in the analyses for either beverage condition or couple type (e.g. DV vs. DNV).

Using the EEGlab plugin CSDtoolbox (Kayser and Tenke, 2006) in Matlab, data were then transformed using the current-source density (CSD) transformation, which has been shown to produce frontal neural sources that are more predictive and reliable estimates of motivational states and traits. The CSD transformation is also a more accurate index of frontal asymmetry as it reduces sources of activation that are not localized to frontal regions of the brain (Smith *et al.*, 2017). Resting data were then parsed into 2 s epochs with a 75% overlap. Power density was estimated using the Goertzel algorithm over 2 s hamming windows with a 500 Hz sampling rate and default 50% overlap. Using this method, fast Fourier transformations were performed on epochs extracted from the data, and the power value on each of the windows was averaged. Log-transformed alpha-power density (8–13 Hz) was obtained for two frontal (F3,F4) and two posterior (P3,P4) electrode sites and used to calculate asymmetry scores [i.e. ln[right(F4,P4)] – ln[left(F3,P3)]). Due to alpha activity being associated with decreased neural activation, higher asymmetry scores are read as increased left alpha activity.

Emotion regulation task. The approach for studying emotion regulation in the present study has been used in several previous studies (Dan-Glauser and Gross, 2013), but we utilized participant-tailored stimuli (video clips of respective partner's evocative behavior). In the WATCH condition, participants were instructed to let their emotional experience occur naturally, and to pay attention to how they felt during the clip. In the DO NOT REACT condition, participants were instructed to attempt to suppress any feelings of emotion so as to prevent an observer watching physiological recordings from knowing that an emotional response had occurred. A total of 50 unique video clips between 4 and 8 s in length were used in the task; 25 evocative and 25 neutral. Each stimulus was presented twice: once in the WATCH condition and once in the DO NOT REACT condition. On each block of trials (WATCH or DO NOT REACT), participants viewed the instruction (WATCH or DO NOT REACT; 1.5 s), a blank screen (1 s), fixation cross (1.5 s), blank screen (0.5 s), video clip (4–8 s) and a blank screen (up to 2.5 s). The total amount of time required for the task was approximately 25 min.

Relationship distress. Relationship distress was determined using the total score of DAS (Spanier, 1976). The DAS is a 32-item measure of relationship quality that is divided into four subscales: dyadic consensus, dyadic satisfaction, dyadic cohesion and dyadic affection. Total scores of 97 or less reflect relationship distress. For partners of a couple who did not both have DAS scores <97, the couple was considered distressed if their averaged DAS score was 97 or less. The mean total score in the current study was 94.27 (SD = 20.26, range 52.00–124.00). There were no significant differences in relationship distress between DV and DNV partners ($t = -1.567$, $P = 0.126$). In the current study, Cronbach alpha for the total scale was 0.92.

Intimate partner violence. For the purposes of partner classification, IPV was determined using the revised conflict tactics scale (CTS2; Straus *et al.,* 1996). The CTS2 is 39-item paired self-report and partner report scale developed to assess the use of tactics used by partners in resolving conflict. The CTS2 is comprised of five subscales that include: negotiation, psychological aggression, physical assault, sexual coercion and injury. In using the CTS2 to classify DV and DNV partners, the physical assault subscale was consulted, and a couple was classified as DV if a partner self-reported the use of physical aggression toward his or her intimate partner. The Cronbach alpha for the total scale in this sample was 0.90, and 0.63 for the physical assault subscale.

Anger expression. Anger expression was measured using the STAXI-2 (Spielberger, 1999). The STAXI-2 is a self-report questionnaire that measures the experience, expression and control of anger in both research and clinical samples. The STAXI-2 is comprised of six scales (state anger, trait anger, anger expression-out, anger expression-in, anger control-out and anger control-in). Responses are made on a likert-type scale ranging from 1 (almost never) to 4 (almost always). Trait anger indexes frequent angry feelings and feeling of being treated unfairly. Anger expression-out indexes anger expressed in verbally or physically aggressive behavior directed at others or objects. Anger expression-in indexes the suppression of frequent intense angry feelings. Anger control-out indexes effort expended in the monitoring and prevention of outward experiences and expressions of anger. Anger control-in indexes effort expended in calming down, and reducing angry feelings immediately, which reduces awareness of when assertive behavior is needed in facilitating constructive resolutions to conflict situations. Mean scale responses from the trait anger, anger expression-out, anger expression-in, anger control-out and anger control-in were used for analysis. In the current study, the Cronbach alpha for the trait anger scale was 0.85, anger expression-out was 0.63, anger expression-in was 0.81, anger control-out was 0.82 and anger control-in was 0.86.

Results

Statistical package for the social sciences 24 was used to perform the statistical analyses of the data for this study. Preliminary analyses were conducted to assure no violations of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Because predictions for all analyses were directional, derived from theory and specified in advance, they were evaluated using a one-tailed criterion of significance (Rosenthal *et al.,* 2000). To ensure no significant group differences existed in variables that might explain our patterns of findings, independent sample *t*-tests were conducted on participant sex and time of day that EEG data were recorded. There were no significant differences in diurnal variation by partner type (DV vs. DNV) for the placebo [t (1,35) = − 0.45, $P = 0.66$] or alcohol conditions [t (1,35) = 0.03, $P = 0.98$].

Pharmacological effects of alcohol on frontal alpha asymmetry

To characterize the effects of left FAA under conditions of alcohol, we conducted a repeated-measures analysis of variance (ANOVA) of the baseline condition with beverage condition (alcohol vs. placebo) as the within-subjects variable and partner type (DV vs. DNV) as the between-subjects variable during the baseline condition. A Bonferroni correction was used to correct for multiple comparisons. The expected beverage by couple type interaction did not reach significance [F (1, 36) = 3.93, $P = 0.055$], but the between-subjects effects of couple type revealed a significant difference [F (1, 36) = 4.425, $P = 0.042$, $\eta^2 = 0.109$] (see Figure 1). Contrary to our hypothesis, however, these results suggest that under conditions of alcohol, DV partners evidenced significantly greater relative right frontal alpha power asymmetry, whereas DNV partners evidenced greater relative left frontal alpha power asymmetry.

To ensure that the above reported findings were specific to FAA, analyses on posterior alpha asymmetry were also conducted. There was no significant effect of partner type on posterior alpha asymmetry [F (1, 36) = 0.653, $P = 0.424$, $\eta^2 = 0.018$].

Pharmacological effects of alcohol and evocative partner stimuli on frontal alpha asymmetry

To test our hypothesis that DV partners would exhibit greater left FAA when intoxicated and viewing evocative partner stimuli than DNV partners, we conducted a repeated-measures ANOVA with beverage condition (alcohol vs. placebo), and stimuli type (evocative vs. neutral) as within subjects variables and partner type (DV vs. DNV) as the between subjects variable. A Bonferroni correction was used to correct for multiple comparisons. The expected couple type by beverage condition by stimuli type interaction did not reach significance [F (1, 36) = 0.004, $P = 0.952$], however, there was a significant interaction of beverage condition by stimuli type collapsed across partner type [F (1,36) = 6.744, $P = 0.014$, $\eta^2 = 0.162$] (see Figure 2), and a main effect of beverage [F (1, 36) = 4.570, $P = 0.040$, $\eta^2 = 0.122$] (see Figure 3).

Frontal alpha asymmetry and emotion regulation

To test our hypothesis that DV partners would exhibit greater FAA than DNV partners during our emotion regulation paradigm,

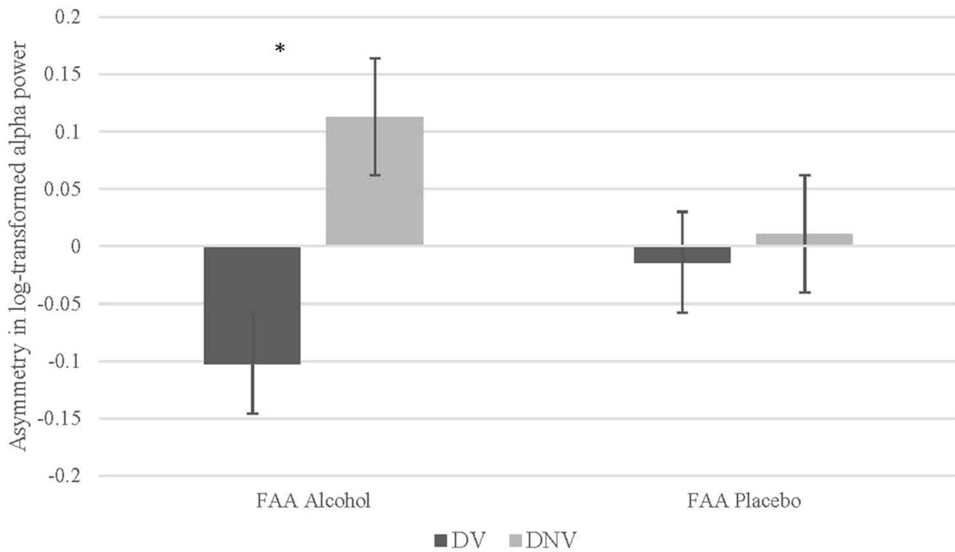

Fig. 1. Analysis of variance of baseline alpha asymmetry power during alcohol and placebo beverage conditions indicating a significant difference of couple type under conditions of acute alcohol intoxication. The expected beverage by couple type interaction failed to reach statistical significance ($P = 0.055$). Participants were on the ascending limb of intoxication, and breath alcohol content at the beginning of the 5-min baseline EEG data collection period was 0.06%. Error bars are standard errors. *$P = 0.042$.

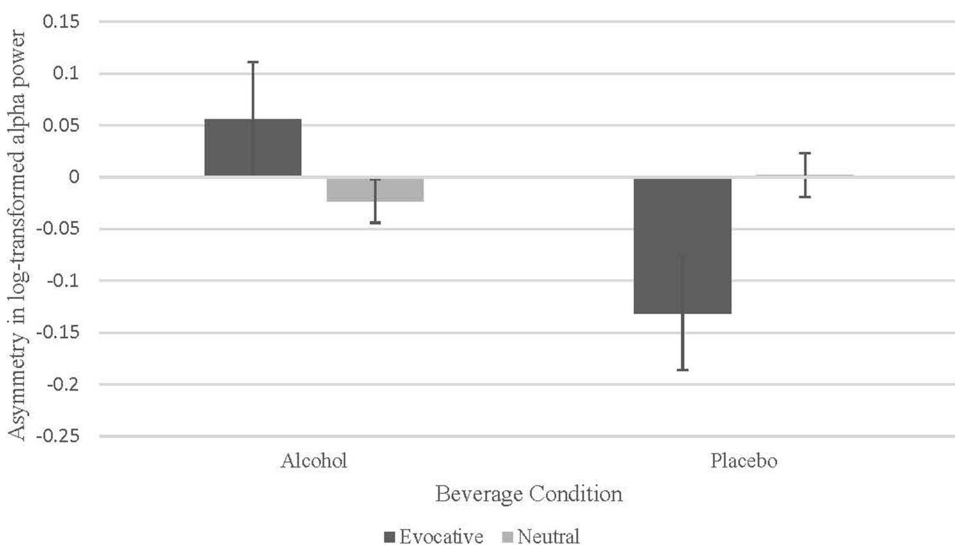

Fig. 2. The present figure represents a statistically significant interaction of beverage (alcohol vs. placebo) by stimuli type (evocative vs. neutral) collapsed across partner type. $P = 0.014$, $\eta^2 = 0.169$. The expected couple type by beverage condition by stimuli type did not reach statistical significance ($P = 0.952$).

we conducted a repeated-measures ANOVA with beverage (alcohol vs. placebo) and emotion regulation condition (watch vs. do not react) as the within subjects variables and partner type (DV vs. DNV) as a between-subjects factor. Although there was no significant between-subjects effect, there was a nearly significant interaction between beverage type and emotion regulation condition [$F = (1, 36) = 4.032$, $P = 0.052$, $\eta^2 = 0.103$], and a significant main effect of emotion regulation condition [$F\ (1, 36) = 7.579$, $P = 0.009$, $\eta^2 = 0.178$]. It appears that asking the participants to 'not react' to their partners' evocative stimuli caused significantly greater right FAA.

Anger expression and frontal alpha asymmetry

Anger expression. A multi-variate analysis of variance was conducted to compare anger expression STAXI subscale scores for DV and DNV partners. Using Pillai's trace, there was no significant effect of couple type (DV vs. DNV) on trait anger, anger expression-out, anger- expression-in, anger control out or anger-control in, $V = 0.106$, $F\ (5, 29) = 0.688$, $P = 0.636$. See Table 1 for means and standard deviations for DV and DNV participants and their partners.

Anger expression and prediction of FAA. Because previous research has found associations between baseline measures of FAA and the STAXI (Spielberger, 1999) subscales of trait anger, anger expression-out, anger expression-in, anger control-out and anger control-in (Hewig et al., 2004), we examined these variables and FAA in the present sample. Multiple regression was used to assess the ability of trait anger, anger expression-out, anger expression-in, anger control-out and anger control-in to predict FAA at baseline. No self-reported STAXI subscale predicted baseline FAA under acute alcohol intoxication in DV participants [$F\ (5, 16) = 1.344$, $P = 0.296$] or DNV participants [F

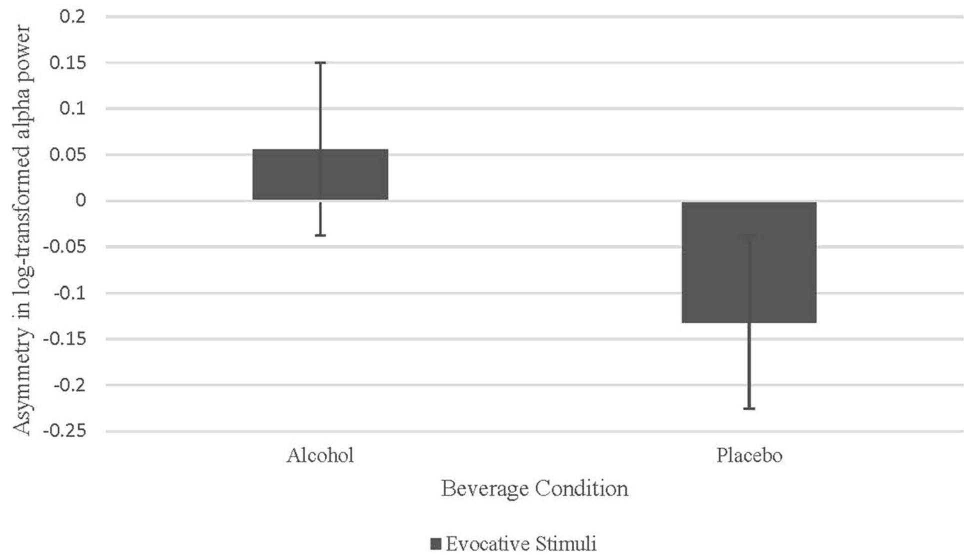

Fig. 3. Main effect of beverage during presentation of evocative partner stimuli collapsed across partner type. $P = 0.040$, $\eta^2 = 0.122$.

Table 1. STAXI anger expression scores for DV and DNV participants and their partners

	DV participant		DV partner		DNV participant		DNV partner	
STAXI subscale	M	SD	M	SD	M	SD	M	SD
Trait anger	18.59	4.66	20.18	5.41	19.06	7.08	16.93	4.94
Anger expression-out	16.73	3.03	17.05	3.50	15.94	3.79	15.64	3.02
Anger expression-in	18.91	6.10	17.59	4.68	18.13	3.91	19.86	4.96
Anger control-out	22.36	4.71	21.86	4.44	21.87	4.38	24.57	5.16
Anger control-in	21.14	5.25	21.55	4.74	22.63	5.06	23.14	5.13

(5, 8) = 0.678, P = 0.652]. Nor did any self-reported STAXI subscale predict DV FAA under acute alcohol intoxication when viewing evocative partner stimuli in the emotion-regulation task [$F = (5, 16) = 1.080$, $P = 0.410$] or DNV partners [F (5, 8) = 0.678, $P = 0.652$].

Anger expression and prediction of FAA in the context of couple conflict. Because we argue that IPV is best understood in the context of conflict between two partners, we also examined partner self-reported experiences of anger as predictors of DV and DNV participants' FAA in separate multiple regression analyses. The self-reported anger experiences (STAXI trait anger, anger control-in, anger expression-in, anger expression-out and anger control-out) of the partners of DV participants were used to predict respective DV participants' FAA under acute alcohol intoxication when viewing evocative partner stimuli in the emotion-regulation task. This model predicted 67.4% of the variance in DV partner FAA, R squared change = .674, F change (5, 15) = 6.21, $P = 0.003$. Three anger experience scales were statistically significant. The partner self-reported anger control-out ($\beta = -1.23$, $P = 0.001$) scale recorded a higher standardized beta value and accounted for 40% of the variance in this model. Anger control-in ($\beta = 0.63$, $P = 0.022$) accounted for 14% of the variance in the model and anger expression-out scale ($\beta = -0.57$, $P = 0.024$) accounted for 13.7% of the variance in the model (see Table 2 for linear model.).

Similarly, multiple regression was conducted to assess the ability of the self-reported anger experiences (STAXI trait anger, anger control-in, anger expression-in, anger expression-out and anger control-out) of the partners of DNV participants were used to predict respective DNV partners' FAA under acute alcohol intoxication when viewing evocative partner stimuli during the emotion-regulation task. Unlike DV partners, however, the model did not significantly predict DNV partner FAA [F (5, 8) = .462, $p = .76$] nor were individual subscales statistically significant.

Discussion

The current study is the first pharmacological study of the effects of alcohol on FAA in DV and DNV partners. Contrary to our hypothesis, under acute alcohol intoxication, DV partners exhibited significantly greater relative right resting FAA compared to DNV partners who exhibited significantly greater relative left resting FAA. This finding is the most novel of the current investigation, and is the first study to identify a physiological quantification of the affective-motivational changes that differentiate violent from nonviolent partners. Previous work has suggested that right FAA is associated with withdrawal motivation, negative emotional experiences or being blocked from acting on anger (Harmon-Jones and Gable, 2018). Right FAA has also been associated with a tendency toward rumination (Kelley et al., 2013). Because there were no group differences in characterological experiences of anger expression in the present study, future work should investigate the role of rumination in this population. Although we controlled for relationship distress in our study, it is conceivable that relationships where physical aggression is present are qualitatively more stressful than those that are simply dissatisfied, and that this distress

Table 2. Linear model of partners' anger experiences predictors of DV participants' FAA

	b	SE B	*β*	P
Constant	2.55 (1.26, 3.84)	0.61		P = 0.001
Partner anger expression-out	−0.061 (−0.11, −0.01)	0.024	−0.57	P = 0.024
Partner anger expression-in	−0.008 (−0.04, 0.02)	0.015	−0.10	P = 0.61
Partner anger control-out	−0.105 (−0.16, −0.05)	0.024	−1.23	P = 0.001
Partner anger control-in	0.050 (0.01, 0.09)	0.019	0.63	P = 0.022
Partner trait anger	−0.004 (−0.037, 0.029)	0.015	−0.05	P = 0.80

is not adequately captured by standard relationship satisfaction measures. The benefit of using a measure such as FAA is that FAA appears to transcend self-report or behavior in detecting this level of distress. Also, previous work in our lab has found that DV couples in our studies report significantly more trauma symptoms than the DNV couples do (Miller and Fink, 2017). Although, not completely analogous to the present design, previous work by Bisby *et al.* (2009, 2010) has shown that more intrusive memories were associated with low doses of alcohol. In the present study, low doses of alcohol may allow the intrusion of distressing relationship and/or trauma-related memories that may increase associated negative emotions and rumination, which may be indexed by the greater relative right FAA in our DV partners.

Another interesting finding from our study is the effect of alcohol on FAA when participants were viewing evocative stimuli from their respective partners. After consuming the placebo beverage, both partner types evidenced significantly greater right FAA, but under acute alcohol intoxication, both partner types evidenced significantly greater left FAA. These findings suggest a potential mechanism through which alcohol may be related to IPV in couple conflict. Gray (1988) discussed alcohol as an agent that disables the behavioral inhibition system, and the results of this study appear, at least on the surface, to support this assertion. More recent research on the neurophysiological effects of alcohol indicate that alcohol does not exert an disinhibitory effect, but rather narrows attention so that only the most central or important environmental cues are processed (Steele and Josephs, 1990). This process is commonly referred to as alcohol myopia.

Given the known neurophysiological effects of alcohol on behavior, it appears that partners move from simply experiencing negative emotions when viewing evocative partner stimuli when sober to being motivated to act upon those negative emotions when intoxicated. What behaviors partners choose to resolve the conflict when intoxicated may be different for DV partners versus DNV partners. Previous work suggests that one's learning history is important for understanding the behaviors chosen when resolving close interpersonal conflict. For example, it has been shown that the more physical punishment an individual received as a child, the more accepting he or she is of the use of physical aggression in his or her marriage (Cast *et al.*, 2006). These individuals appear to have learned that when one has conflict with someone with whom he or she has a close personal relationship that physical aggression is an acceptable means of resolving it. For the DNV partners in our sample, it appears that while alcohol consumption may motivate engagement in conflict, the behaviors they choose to resolve it are obviously different.

Last, because we argue that IPV is best understood in the context of couple conflict, we examined the ability of partners' anger experiences to predict DV and DNV participants' FAA, and a very interesting pattern emerged among our DV participants and their partners. The anger experiences the partners of our DV participants' accounted for 67% of the variance in the FAA of our DV participants when they were intoxicated and viewing evocative stimuli. The most interesting aspect of this finding is in the examination of the statistically significant variables of the model that predicted FAA.

The partner anger control-out scale, which describes individuals who expend a great deal of energy monitoring and preventing their outward manifestations of anger accounted for most of the variance in the model. In this instance, as partner anger control-out scores decreased, DV partner FAA increased. Also, the partner anger control-in scale, which describes individuals who expend so much energy calming down as soon as possible they are unable to behave in constructively assertive manners, was also a significant predictor in the model. As anger control-in scores increased, so did DV partner left FAA. Last, the partner anger expression-out scale, which describes individuals who frequently express their anger in verbally aggressive manners through contemptuous, critical or insulting comments or physically aggressive behavior, was also a significant predictor in the model. As partner anger expression-out scores decreased, DV partner left FAA increased. The overall picture this paints for alcohol-related IPV is that instead of healthy, direct expressions of dissatisfaction or anger that these couples engage in dysregulated and dysfunctional conflict that motivates the DV partner to engage (as indexed by their increasing left FAA), which has the end effect of escalating the conflict to the point of physical aggression. These findings also confirm previous behavioral examinations, which found that DV couples become more psychologically abusive, emotionally aggressive and increasingly physiologically aroused as their conflict continues because of dysfunctional patterns of interaction (Babcock *et al.*, 1993; Jacobson *et al.*, 1994; Gottman *et al.*, 1995; Frye and Karney, 2006). Our current work contributes to this body of literature in describing how alcohol acts as an accelerant to these dysfunctional behavioral patterns in DV couples' conflict.

Limitations. There are several limitations of this study that may limit the generalizability of the findings. These include that the sample size is small, and no a priori statistical power analyses were conducted. The participants in the present study were drawn from a larger study investigating over-arousal as a mechanism between alcohol use and IPV. Because of this, we did not conduct an a priori statistical power test to determine the sample size. It should be noted, however, that the effect sizes reported as well as the correlations in the multiple regression are large.

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Conflict of interest

None declared.

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