Alcohol and Emotion: Analyzing Convergence Between Facially-Expressed and Self-Reported Indices of Emotion Under Alcohol Intoxication

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Author Note

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Conflicts of Interest

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Abstract

Objective: Emotion measurement is central to capturing acute alcohol reinforcement and so to informing models of alcohol use disorder (AUD) etiology. Yet our understanding of how alcohol impacts emotion as assessed across diverse response modalities remains incomplete. The present study leverages a social alcohol-administration paradigm to assess drinking-related emotions, aiming to elucidate impacts of intoxication on self-reported vs. behaviorally expressed emotion.

Method: Participants (N=60; mean age=22.5; 50% male; 55% White) attended two counterbalanced laboratory sessions, on one of which they were administered an alcoholic beverage (target BAC .08%) and on the other a non-alcoholic control beverage. Participants in both conditions were accurately informed of beverage contents and consumed study beverages in assigned groups of three while their behavior was videotaped. Emotion was assessed via self-report as well as continuous coding of facial muscle movements.

Results: The relationship between self-reported and behaviorally expressed emotion diverged significantly across beverage conditions: positive affect: b=-0.174, t=-2.36, p=0.022; negative affect, b=0.4319, t= 2.37, p=0.021. Specifically, self-reports and behavioral displays converged among sober but not intoxicated participants. Further, alcohol's effects on positive facial displays remained significant in models controlling for self-reported positive and negative emotion, with alcohol enhancing Duchenne smiles 20% beyond effects captured via self-reports, pointing to unique effects of alcohol on behavioral indicators of positive emotion.

Conclusions: Findings highlight effects of acute intoxication on the convergence and divergence of emotion measures, thus informing our understanding of measures for capturing emotions that are most proximal to drinking and thus most immediately reinforcing of alcohol consumption.

Public Health Significance Statement: This study indicates that, while participants' self-reported and behaviorally-expressed emotion held consistent when not drinking, these measures diverged following alcohol consumption. Results further indicated alcohol's effects on positive emotion were not fully captured by self-report, a tool that has been relied on throughout addiction research. As a result, this study highlights the importance of using multiple methods of capturing emotion, including behavioral and self-report methods, when studying alcohol's effects on emotion and drinking behaviors.

Introduction

The relationship between alcohol and emotion has received attention throughout addiction research as a key factor contributing to the development of alcohol use disorder (AUD; Blane & Leonard, 1999). From a motivational perspective, research investigating real-world drinking settings has found support for increased drinking behavior following positive interpersonal experiences (Mohr et al. 2001) as well as in response to periods of negative emotion (Dvorak et al., 2014). Such behavioral results are broadly consistent with prominent theoretical models within the addiction literature; in particular, reinforcement-based models propose that individuals drink both to enhance experiences of positive emotion and to cope with experiences of negative emotion (Cooper et al., 1995). Notably, the extent of emotional rewards derived from alcohol has been linked with key clinical outcomes, with both reduced negative and heightened positive emotion following drinking having been identified as predictive of both binge drinking and drinking-related problems longitudinally (Venerable & Fairbairn, 2020). Consequently, understanding the relations between affect experiences and patterns of alcohol use represents a critical step in untangling the complex web of interacting factors driving drinking behaviors and, ultimately, AUD development.

The social context in which drinking occurs also plays an essential role in shaping the relationship between affect and the development of drinking patterns. Drinking frequently occurs within social environments where other individuals are present (Heath, 2000), adding relational and contextual dimensions that are vital to understanding the nature and mechanisms of alcohol reinforcement (see Fairbairn et al., 2018). From a theoretical perspective, social models of alcohol's effects implicate alcohol in the enhancement of social interaction quality and interpersonal enjoyment, indicating alcohol may operate by way of positive reinforcement in facilitating easier, more pleasant social interactions, as well as by way of negative reinforcement in alleviating social stressors (Fairbairn & Sayette, 2014). Implicit within this model is the proposal that social context plays an essential role in shaping the relationship between emotion and drinking, with positive social experiences playing both enhancement and reinforcement roles in motivating alcohol use (Kuntsche et al., 2006; van Damme et al., 2013). Motivationally, emotion-related experiences within social contexts have been found to exert powerful influences on drinking behaviors, with individuals endorsing desires for social conformity and alleviating social stressors as common reasons not only for drinking, but for alcohol consumption at the level of AUD, within social settings and across clinical and subclinical populations (Cooper et al., 2014; Terlecki & Buckner, 2015). Meta-analytic research examining alcohol's *effects* on emotion, however, has found mixed support for its role in buffering social stress (Bresin, 2019). Such results, therefore, establish a need for refined, comprehensive assessments of affect as a means of more thoroughly documenting alcohol's effects when consumed in a social context.

Although the value of capturing both emotion and context within alcohol research may be clear, effective methods for doing so have proven challenging to develop. While self-report has undoubtedly been key in the fields of both addiction and emotion science, alcohol has been posited to impact such processes as introspection (Schmidt et al., 2013) and emotional insight (Austin et al., 2020), higher-order cognitive skills which might be expected to influence individuals' ability to consciously interpret and report their emotional experiences both in-the-moment and retrospectively. One tool that has been argued as well-suited to addressing these concerns is the Facial Action Coding System (FACS), a method of objectively parsing an individual's facial expression by dividing it into discrete muscle movements, or action units (AUs), in frame-by-frame analysis (Ekman & Friesen, 1978). The interpretability of context-specific human facial expression has received support across culturally diverse samples (Cowen et al., 2021), indicating the potential value and sensitivity of facial expression as a window to emotional experience as opposed to retrospective self-report. In particular, the “Duchenne smile,” characterized by the presence of both raised lips and crinkling around the eyes, has been identified as an indicator of positive emotional experience in both meta-analytic (Gunnery & Ruben, 2016) and experimental (Surakka & Hietanen, 1998) work (although see Girard et al., 2021). Within the addiction literature, FACS has been used to investigate experiences of anger (Parrott et al., 2003), as well as positive (Sayette et al., 2019) and negative emotion (Eckhardt et al., 2021), demonstrating its utility as a tool in exploring relations between substance use and affect. Perhaps most importantly, however, employing FACS within addiction research not only allows for unobtrusive measurement of real-time emotion within social interaction settings, but also facilitates capturing moment-to-moment changes in affect as these manifest in response to consumption over time—proximal effects that represent the most direct mechanism reinforcing drinking as an emotionally-rewarding behavior (van Doren et al., 2024).

Although FACS has received support across experimental paradigms, important critiques have been raised regarding correlations between coded behavioral expressions of emotion and other measures of emotional experience, including self-report. For instance, meta-analyses of basic emotional expressions have found limited support for correlations between FACS expressions and other indices of emotion, both in terms of broad categorization and emotional intensity (Durán & Fernández-Dols, 2021). At the level of theory, some have levied critiques at the foundational concept of inferring emotion from facial expression, particularly in areas involving negatively-valanced emotions (Barrett et al., 2019). Furthermore, variation in situationally-linked facial expression may exist at multiple levels of analysis – for instance, internal variation in emotional experience may be responsive to the broader environmental context and, in turn, be associated with unique behavioral expressions (Hareli et al., 2019; Hess et al., 2020). More broadly, social settings and processes may influence both behavior and affect, thus simultaneously impacting the already complex relationship between these variables and patterns of drinking (Hollinsaid et al., 2023; Kraut & Johnston, 1979; Reschke et al., 2018). However, limited research has yet to isolate the states and circumstances under which facial and felt emotions match vs. diverge, as well as the mechanisms of alcohol consumption that might underlie such variability.

Regarding research employing FACS in addiction science, findings from prior studies have suggested that contradictory facial expressions may emerge in cases of substance ambivalence and lead to behaviorally expressed emotions which diverge from self-reports (Griffin et al., 2008). Similar discrepancies between FACS and self-report have also been observed in cases relating to self-reported urge to smoke (Sayette & Hufford, 1995), further illustrating the potential of facial analysis to reveal information about emotional experience that is distinct from self-report. However, our understanding of the extent to which such effects might extend to the domain of acute alcohol reinforcement is incomplete. Prior research has explored alcohol's effects in group context using multimodal affect assessment and between-participant designs, comparing affect outcomes among groups of participants assigned to receive alcohol to those receiving none (see Sayette et al., 2012). Results of this research indicated significant effects of alcohol in enhancing both self-reported and behaviorally expressed emotion. However, no study to our knowledge has examined the effect of alcohol on intra-measure associations. It is notable that, in light of individual-level variability in expressiveness as well as introspection capabilities (Hull, 1981; Kuppens & Verduyn, 2017), within-subject designs in which participants serve as their own controls may best capture variability for (inherently) participant-level links between reported and expressed emotion. The present study employs a within-subject design to explore the acute effects of alcohol on both facially displayed and self-reports of emotion, so permitting the comparison of the same participant cohort at moments of intoxication as well as sobriety.

The present study employed an alcohol-administration design and multimodal affect assessment to explore the extent to which the relationship between self-reports and facial expressions of emotion converge vs. diverge during alcohol intoxication (see Bujarski & Ray, 2016 for discussion of laboratory alcohol-administration paradigms). This study involved frame-by-frame extraction of participants' emotional facial display throughout alcohol consumption, affording power to detect affect effects emerging throughout the course of a drinking episode. Participants in this study completed two laboratory beverage-administration sessions, during one of which they consumed an alcoholic beverage and during the other a non-alcoholic control beverage. In light of the utility of free-form social interaction in eliciting a range of emotional experiences (Fairbairn et al., 2018), as well as its relevance for the understanding of drinking behaviors (Fairbairn & Sayette, 2014), experimental procedures took place in the context of triadic groups.

The aims of this study were as follows. First, we aimed to explore the impact of alcohol on facial displays of emotion (Aim 1), examining the extent to which prior work employing between-subjects designs (Sayette et al., 2012) might replicate within in the current within-subjects framework. Building on prior work, here we hypothesized that alcohol would substantially increase the prevalence of Duchenne smiling, particularly during the portion of the interaction in which pharmacological effects of alcohol are most pronounced (i.e., after BAC levels had begun to rise). In light of the mixed literature surrounding negative displays of emotion (Barrett et al., 2019), we had no firm hypotheses surrounding negative facial expressions. Second, we aimed to explore relations between self-report and behavioral indices of emotion (Aim 2). Here, derived from the literature exploring alcohol's effects across cognitive domains (Schmidt et al., 2013; Steele & Josephs, 1990) and emotional insight (Austin et al., 2020), we predicted increased divergence in behavioral vs. introspection-based measures of emotion in the alcohol condition as compared to the control condition[1].

Transparency and Openness

All data and analytic code required to replicate results of this study are provided at the following link: https://osf.io/k3qnx/?view_only=bc62932073e44decbe8d89358fcc0683 (Caumiant, 2024). All study procedures were approved by the University of Illinois at Urbana-Champaign Institutional Review Board (IRB Protocol Number 16263) and conducted in accordance with the sixth revision of the Declaration of Helsinki. Study hypotheses were not pre-registered.[2] We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study below.

Methods

Participants were recruited through online advertisements, flyers and handouts distributed in the local community, and participant referrals. The final participant sample consisted of 60 young, healthy individuals who reported social drinking (50% female; 50% male). All

[1] For the purposes of interpreting results, "convergence" was defined as situations in which measures that ostensibly sought to capture the same emotion corresponded with one another (i.e. self-reported positive affect and Duchenne smiling), while "divergence" was defined as any situations in which these measures were not associated, including both attenuated and opposing relationships.
[2] This project—including participant data collection as well as the analysis of data—was several years in the making. Early models examining hypotheses for this study were run prior to the time during which study pre-registration was widespread in addiction science.

participants completed study procedures in 2016. Of study participants, 55% identified as White, 11.7% as Black, 5% as Hispanic, 20% as Asian, and 8.4% as Other/Multiracial. Regarding the composition of participant drinking groups, 85% of groups were mixed-race. Additionally, given that prior research has found that primary gender differences emerge between all-male and all-female groups, whereas relatively little variability is explained by mixed-gender groups (Sayette et al., 2012; Fairbairn et al., 2015), we opted to examine same-gender groups in the current research. All participants were between the ages of 21 and 28 (M=22.5, SD=1.9), with younger ages being targeted to allow for the capturing of alcohol use behaviors prior to an age at which more severe forms of Alcohol Use Disorder (AUD) might be expected to have developed. Of participants, 56.7% had completed four or more years of college education. Interested participants completed an in-person screening interview, and screen-out conditions included pregnancy, prior diagnosis of an AUD, or diagnosis of a medical condition that contraindicated alcohol consumption (e.g., liver disease). All participants provided informed consent and affirmed they were comfortable with study procedures. During intake interviews, participants reported drinking an average of 10.3 days a month (SD=5.45) and drinking 4.03 drinks per drinking occasion (SD=5.45).

Sample size was determined a-priori and in light of the multiple experimental visits attended by participants. Assuming a 2-tailed test of significance and within-subjects alcohol-administration design with α= 05, the current sample size yields 80% power to detect alcohol effects on behavioral and self-reported emotion outcomes that are small to medium in magnitude (d=0.339; r^2=.028; Faul et al., 2007). Prior reports have been published based on this laboratory beverage-administration dataset that have focused on self-reports of affect (Fairbairn et al., 2018; Venerable & Fairbairn, 2020). Of note, however, while this project involved a multi-year behavioral coding effort, no publication has previously reported facial data emerging from this project.

Procedure

Eligible participants were invited to the laboratory for a series of in-person visits held over the course of one week (see Fairbairn et al., 2018 for a full account of study procedures). Participants attended visits in groups of three strangers who had not met prior to study enrollment. The social configuration was chosen to allow for the creation of a social drinking context during the beverage administration phase of the study while simultaneously standardizing the interaction experience across groups by ensuring no pre-existing relationship among participants. During the first (baseline) visit, participants signed informed consent, completed a series of questionnaires, and were oriented to ambulatory research procedures outside the lab unrelated to the current study (for full discussion of study procedures, see Fairbairn et al., 2018). Participants then scheduled two follow-up experimental sessions, one to be held four days and the other to be held one week after this initial appointment.

Subsequent experimental appointments served as either alcohol-administration or "control" sessions, with the order of these visits being counterbalanced across groups. Immediately prior to each drinking session, participants completed pre-drink self-report measures of affect (see *Measures* below). During alcohol-administration sessions, participants were served an alcoholic beverage that was adjusted for participants' height and weight in order to attain a peak breath alcohol content (BrAC) of approximately .08% (0.82 g/kg alcohol dose for men, 0.74 g/kg for women; see Sayette et al., 2012 for full alcohol dosing procedures). During control sessions, participants received an isovolumic quantity of a non-alcoholic beverage. Of note, participants in the current research were accurately informed of whether they were receiving an alcoholic or non-alcoholic drink at the beginning of beverage administration; this study did not include a placebo condition (an experimental manipulation involving deception surrounding the contents of non-alcoholic beverages) due to concerns regarding unanticipated expectancy and compensatory effects observed with placebo manipulations in prior alcohol-administration studies (see Testa et al., 2006; Fairbairn et al., 2015), and in light of our interest in mirroring drinking settings as they might manifest outside the lab.

For both alcohol and control sessions, the beverage administration phase lasted 36 minutes, and participants completed each phase while accompanied by the members of their drinking group (see Figure 1). The beverage administration phase also provided an opportunity for unstructured social interaction—participants engaged in casual social conversation while seated around a shared drinking table. In both the alcohol and control condition, participants' beverage doses were divided into three equal-volume servings, and these servings were evenly spaced across the 36-minute interaction (at min 0, min 12, and min 24); participants were instructed to endeavor to pace their consumption of each beverage serving as evenly as possible within each of these 12-minute intervals. Experimenters entered the room at twelve-minute intervals (min 12 and again at min 24) to refill drinks, but participants were otherwise monitored only by video (see below). Following the beverage administration phase, participants supplied breathalyzer readings (Intoximeters Alco-Sensor IV) and completed post-drink self-reports of their current affect. The laboratory drinking room was outfitted with cameras trained on participants' faces throughout the social drinking period in order to capture participants' emotion-related behavior during active consumption (see Figure 1). Participants were initially told that these cameras were only employed to ensure they remained compliant with beverage-consumption instructions—deception that was employed in order to ensure participants did not modify their nonverbal behaviors due to concerns that their expressions were being scrutinized by experimenters. All participants were debriefed in the use of deception following study procedures and provided informed consent regarding the use of their video data for facial analysis. Participants who completed all study procedures were compensated 200 USD (see also Fairbairn et al., 2018).

Measures

Self-Reported Emotion

To avoid anchoring effects, we employed different measures to assess mood before vs. after alcohol consumption. Prior to alcohol consumption, participants completed the Positive and Negative Affect Schedule (PANAS) to measure pre-drink affect. The PANAS is a 20-item measure containing 10 items keyed to positive affect (e.g., “enthusiastic,” “excited,” and “interested”) and 10 items keyed to negative affect (e.g., “scared,” “afraid”, and “upset”), all of which are rated on a 5-point Likert scale (Watson et al., 1988).

Following each drinking session, participants completed a unique eight-item affect measure that included items assessing both positive affect (“cheerful,” “upbeat,” “content,” and “happy”) and negative affect (“sad,” “irritated,” “bored,” and “annoyed”) and that served as our primary self-report emotion measure for subsequent analyses. This emotion measure structure, which has been employed across studies of drinking and emotion (see Fairbairn et al., 2018), has been supported via exploratory factor analysis (Venerable & Fairbairn, 2020) and validated in studies encompassing >1000 participants (Fairbairn & Sayette, 2013; Fairbairn et al., 2022). This measure has also demonstrated internal consistency in capturing positive and negative affect (Ariss et al., 2023; Venerable & Fairbairn, 2020). As noted previously, we opted to assess broad negative affect (vs discrete negative states) to facilitate FACS interpretations (see Barrett et al., 2019), as well as to maintain consistency with prior work employing similar paradigms (e.g., Austin et al., 2020).

Behavioral Expressions of Emotion

Each frame of participants' video data was evaluated via the facial action coding system (Ekman & Friesen, 1978). Of particular interest in this study was the Duchenne smile, which has been widely studied in emotion research as an indicator of genuine positive emotion (Ekman et al., 1990). Following data collection, a team of research assistants certified in FACS coding evaluated participant videos for the presence of Duchenne smiles throughout beverage administration sessions; specifically, the timing and duration of AU6+12 ("cheek raiser" plus "lip corner puller," indicating a smile with the characteristic eye crinkle of the Duchenne smile; see Ekman & Friesen, 1978) was coded as a proxy measure of expressed positive emotion (Cohn et al., 2007), and the precise onset and offset of each instance of this AU was coded throughout the course of the 36-minute interaction. AU12 without AU6 was coded as an instance of a "social smile," and AU14, AU15, AU20, and/or the presence of AU9, in the absence of AU12, was coded as an instance of negative affect. Taken together, the present study involved the coding of approximately 7.8 million frames of video data. All video files were double-coded by two certified FACS raters, with inter-rater reliability varying across expression types, emerging as strongest in the domain of positive emotion (agreement calculated at the level of the second; positive affect K=0.77; social smiles K=0.79; negative affect K=0.68; see Landis & Koch, 1977; McHugh, 2012 for interpretation) and reflecting rates of interrater agreement similar to those reported in prior alcohol-administration FACS research (e.g. Sayette et al., 2012). Given reliability scores were acceptable but not exceptional, cases of discrepancy were evaluated by a third certified coder, and all disagreements between coders were later discussed and resolved through consensus.

Data Analysis Plan

Analyses employed multilevel models predicting FACS as outcome while accounting for the clustering of observations at the level of the session, individual, and social group via random intercepts (Kenny et al., 2002). In addressing our primary study aims, we identified multiple key relations of interest. First, to address Aim 1 exploring the impact of alcohol on facial displays of emotion, we examined the main effect of alcohol on FACS, as well as exactly *when* during the social interaction behavioral emotion indicators emerged by exploring the interaction between time and beverage condition in predicting FACS. Second, to address Aim 2, we quantified the effect of alcohol on facial expression above and beyond self-reported emotion by examining the main effect of beverage condition on FACS while controlling for self-reported affect; furthermore, as an additional analytical approach to this question, we examined the interaction between self-report and beverage condition in predicting FACS results.

For analysis, FACS data were aggregated into one-minute bins representing our three main behavioral emotion displays (i.e. Duchenne smile, social smile, and negative affect), with each bin reflecting the duration spent displaying the corresponding AUs in terms of average number of seconds per minute of the social interaction. These one-minute binned facial expressions were then examined as outcome variables in all primary analyses, with beverage condition, beverage-administration time-interval, and self-reports of emotion entered as predictors. As outcomes were both clustered and non-normally distributed, generalized linear mixed models (GLMMs) were used assuming a Poisson distribution and overdispersed residuals. For all generalized models, *ERR* [*Event Rate Ratio* or *Exp(b)*] is provided as a risk ratio reflecting the relative percentage change (increase or decrease) in the dependent variable per unit increase in the independent variable (Cohen, 2013). Models examining the main effect of alcohol on self-reports employed the same models but with the gaussian family, accounting for the clustering of observations within individuals and three-person groups, with predictor and outcome being converted to z-scores to yield approximates of the standardized effect size metric Beta *(β)*.

Results

Beverage Manipulation Check

In alcohol-administration laboratory sessions, participants were on the ascending limb of the BrAC curve immediately following the group consumption period (*M*=.064%; *SD*=.01), ultimately rising to a peak BrAC of .074% (SD=.01) about 60 minutes post-interaction (Fairbairn et al., 2018). Subjective intoxication ratings, provided on a scale of 0 (“not intoxicated at all”) to 100 (“the most intoxicated I’ve ever felt”), indicated participants in the alcohol condition felt subjectively intoxicated immediately following beverage consumption (*M* =38.25; *median*=35.00; *SD*=17.77). Participants in the control condition largely did not experience subjective post-drink intoxication (*M* =.58[3]; *median*=0; *SD*=3.92).

Aim 1: Effects of Alcohol on Emotion

Behavioral Measures of Affect

Analyses revealed a main effect for beverage condition on Duchenne smiling, *b*= 0.222, *ERR*=1.249, *t*= 3.17, *p*=0.003, as well as negative facial expression, *b*=-0.172, *ERR*=0.842, t=-.289, *p*=0.006. Event rate ratios indicated participants spent approximately 25% more time smiling, and 16% less time displaying negative facial expressions, in alcohol compared to

[3] Despite being informed they had received a non-alcoholic beverage, two participants nevertheless reported small post-drink SIS (ratings of 2.00 and 5.00, respectively).

control sessions. In contrast, no main effect was observed for beverage condition on social (i.e., non-Duchenne) smiles, b= 0.083, *ERR*=0.842, p= 0.112, suggesting that observed relations may be specific to affectively linked expressions as opposed to smiling and/or pro-social behaviors more broadly. Means across alcohol as compared to control sessions, as well as intraclass correlation coefficients for behavioral measures of affect at the level of the group, are presented in Table 1.

Next, in order to explore the extent to which effects changed as intoxication level increased throughout beverage administration, we examined shifts in facial expression across time epochs during the course of the 36-minute drinking period. Consistent with sub-divisions applied in prior alcohol-administration studies exploring behavioral-affective displays during active consumption (e.g., Kirchner et al 2006; Sayette et al., 2012), as well as theorizing surrounding broad time intervals over which pharmacological effects of alcohol are likely to emerge (Morean & Corbin, 2010), we explored change over time in the context of analyses subdividing the interaction into three 12-minute intervals. Regarding results for Duchenne smiling, analyses revealed a significant interaction between time interval and beverage condition in predicting Duchenne smiling, b= 0.097, *ERR*=1.102, t= 2.54, p= 0.010. Analyses targeting the first 12-minutes of the interaction (an interval prior to the time period during which potent pharmacological effects of alcohol typically emerge) revealed no significant main effect of beverage condition on Duchenne smiling, b=0.132, *ERR*=1.141, p=0.112. In contrast, these same effects reached significance during the second 12-minute interval, b=0.261, *ERR*=1.298, p=0.002, pointing to a 30% increase in Duchenne smiling in the alcohol condition relative to the control condition, alcohol effects that remained significant and increased slightly to 34% during the final 12 minutes of the interaction, b=0.297, *ERR*=1.346, p<.001. Thus, results suggest that effects of alcohol on Duchenne smiling magnify as drinking progresses and intoxication level increases.

Regarding negative facial displays, whereas means tended in the same direction, the interaction of time interval and beverage condition did not emerge as significant, b= -0.048, ERR=0.953, t=-1.41, p=0.160. We note that there remains some uncertainty regarding the extent to which operationalization of negative emotion from negative facial expressions is valid (Barrett et al., 2019). Given this, in conjunction with our preliminary interaction findings pointing to no significant effects of progressive intoxication on negative facial displays, subsequent models presented below focus on positive (as compared to negative) facial expressions. However, complete results for negative facial expression are presented in Table 2.

Self-Report Measures of Affect

As reported elsewhere (Fairbairn et al., 2018),[4] alcohol effects were also observed via self-report indicators. In examining self-report measures of affect, higher positive affect, b= -0.76, β=-.35, t= -4.65, p<.0001, and lower negative affect, b= 0.37, β= .31, t=4.14, p<.0001, were observed following beverage administration in alcohol sessions (positive affect: M= 4.60, SD= 1.00; negative affect: M= 1.20, SD= 0.37) when compared to control sessions (positive affect: M= 3.83, SD=1.10; negative affect: M=1.57, SD= 0.62). Intraclass correlation coefficients of self-report measures of affect at the level of the group are presented in Table 1.

Aim 2: Interaction Between Beverage Condition and Duchenne Smiling

To determine the extent to which the facial measures we focus on here yield information above-and-beyond that provided by self-reports, we next ran analyses examining the effect of beverage condition on Duchenne smiling in models that also control for reported emotion. In

[4] Effects of alcohol on self-reports of affect have been reported previously among the sub-sample of participants in this study who also completed ambulatory procedures (Fairbairn et al., 2018)

models including self-reports of positive affect and negative affect as covariates, effects of alcohol on Duchenne smiling remained significant: positive affect, *b*=0.170, *EER*=1.19, *t*=2.14, *p*=0.037; negative affect, *b*=0.186, *EER*=1.20, *t*=2.42, *p*=0.019. For both of these analyses, alcohol increased Duchenne smiling approximately 20% even after effects captured via self-reports of affect were controlled. These findings suggest: 1) FACS appears to provide unique information surrounding alcohol beyond that captured via self-report; 2) FACS and self-report measures may diverge in important ways when it comes to the examination of alcohol.

Next, we explored our primary hypotheses surrounding the effects of alcohol on inter-measure convergence across reported as compared to expressed measures of emotion. In exploring these hypotheses, models predicting Duchenne smiling revealed a significant interaction between beverage session and self-reported positive affect, *b*=-0.174, *ERR*=0.840, *t*=-2.36, *p*=0.022, as well as between beverage session and self-reported negative affect, *b*=0.4319, *ERR*=1.540, *t*= 2.37, *p*=0.021. Specifically, results suggested that the relationship between self-reported and displayed emotion reached significance in the control session but not the alcohol session (see Figure 2). In the control session, there was a significant relationship between the total duration of Duchenne smiles and self-reported post-drink positive affect, *b*=0.146, *ERR*=1.157, t=2.48, *p*=0.015, indicating a 16% increase in time spent displaying a Duchenne smile per 1-unit increase in self-reported post-drink positive affect. There was also a significant relationship between the total duration of Duchenne smiles and self-reported post-drink negative affect, *b*=-0.201, *ERR*=0.818, t=-2.04, *p*=0.045, indicating an 18% decrease in time spent displaying a Duchenne smile per 1-unit increase in self-reported post-drink negative affect. In contrast, in the context of alcohol sessions these effects had disappeared, with no significant relationship emerging between Duchenne smiling and positive affect measures, *b*=-0.284, *ERR*=0.753, t=-0.44, *p*=0.656, or negative affect measures, *b*=0.231, *ERR*=1.256, t=1.40, *p*=0.166. Therefore, as these pertain to study hypotheses, results suggest divergence across self-report and behavioral affect indicators with the consumption of alcohol, with affect indicators converging at times of sobriety but diverging during moments of intoxication.

In an effort to parse potential confounds and elucidate mechanisms underlying effects, we next performed a range of supplementary analyses probing these primary study findings. One factor that might potentially drive non-significant relations observed between self-reports and behavior in the alcohol session is differential levels of variability across sessions (e.g., selective floor/ceiling effects); to address this, we examined variability of affect measures within each beverage session. Results demonstrated considerable variability for positive FACS expressions in both alcohol (range=58.77 seconds, SD=11.60) and control (range=55.07 seconds, SD=10.83) sessions. Variability was also observed in post-drink self-report affect measures for positive affect (alcohol: range=5.00, SD=.99; control: range=4.75, SD=1.09). For self-reported negative affect, variability was more restricted (alcohol: range=1.50, SD=.37; control: range=3.00, SD=.62); although reasonably consistent across both beverage sessions, we note that participants were likely to enter the study with low levels of negative emotion, thus limiting potential interpretations of findings relating to this self-report measure. Taken together, however, these analyses indicate that our results were unlikely to be driven by differential variability across sessions.

Next, we conducted analyses aimed at differentiating between expressions of genuine “felt” positive emotion and mere social smiling “displays,” To achieve this, we replicated primary convergence analyses substituting social smiles (in place of Duchenne smiles) as outcome. Results indicated there was no significant interaction between beverage session and self-reported positive affect in predicting these (non-genuine) social smiles, *b*=-0.038, *ERR*=0.963, *t*=-0.70 *p*=0.488, suggesting reported results of observed Duchenne smiles are more likely specific to genuine experiences of positive emotion as compared to generalizable across all non-affect linked behavior.

Finally, given observed evolution in pharmacological alcohol effects across the drink period, we sought to elucidate exactly *when* in the social drinking period the divergence between reported and expressed emotion occurred. In probing the interaction between beverage session and self-reported affect on observed Duchenne smiling, results revealed no significant interaction during minutes 1-12 (positive affect, *b*=-0.172, *ERR=0.842,* t=-1.99, *p*=0.051; negative affect, *b*=0.0480, *ERR=1.049,* t=0.78, *p*=0.436). In contrast, this effect emerged as larger in magnitude for negative affect during minutes 13-24 (positive affect, *b*=-0.128, *ERR=0.880,* t=-1.54, *p*=0.128; negative affect, *b*=0.521, *ERR*=1.685, t=2.64, *p*=0.010) and reached significance across both positive and negative affect during minutes 25-36 (positive affect, *b*=0.079, *ERR*=1.082, *t*=-2.69, *p*=0.009; negative affect, *b*=0.477, *ERR*=1.610, *t*=2.41, *p*=0.019). In sum, results supported expectations that effects of alcohol on behavioral affect displays would be most apparent later in the social interaction, after the effects of alcohol intoxication had begun to take hold. Furthermore, and as might be anticipated, findings exploring the pre-drink PANAS measure indicated no significant interaction between beverage session and self-reported pre-drink affect in predicting Duchenne smiling, *b*=-0.012, *ERR*=0.989, *t*=-1.29, *p*=0.202.

Discussion

The present study combined group-based alcohol administration with in-depth analysis of facial expression, aiming towards informing a fuller understanding of the effects of alcohol consumption on affect. Results captured significant effects of alcohol on facial displays of positive emotion as indexed by the Duchenne smile, with these effects expanding in magnitude across epochs of the social drink period as intoxication level increased. Of note, alcohol’s effects on these positive emotional displays remained significant even in models controlling for self-reported positive and negative affect, with alcohol enhancing Duchenne smiles 20% beyond effects observed for self-reports, thus suggesting unique alcohol effects as captured via behavioral affect indicators. In contrast, effects of progressive intoxication did not reach significance in predicting negative (vs. positive) facial displays. Finally, results suggested that the relationship between self-reported affect and displayed emotion was significantly stronger when participants were sober vs. intoxicated, with this relationship failing to reach significance among intoxicated participants. Considered in combination with prior findings, results point to a causal role for alcohol in inducing experiences of positive affect in social context. Results further highlight the value of multi-modal emotional assessment, indicating that behavioral measures may offer unique information beyond that captured by traditional self-report measures in assessing relations between alcohol consumption and affect outcomes, thus enhancing our ability to capture affect in the assessment of alcohol reinforcement.

Regarding findings of analyses exploring main effects of alcohol on facial expressions, results provide support for emotion-enhancement models of drinking motivation, further bolstering a body of work supporting the premise that alcohol consumption may be reinforced by its ability to enhance positive affect (Fairbairn & Sayette, 2014). Prior studies seeking to capture alcohol’s acute reinforcing properties have yielded mixed and sometimes reverse effects—findings that have been attributed to experimental paradigms featuring solitary drinking context and reliance on self-report affect measures (Sayette et al., 2012). To our knowledge, two prior studies have employed systematic facial coding in exploring the effects of alcohol on affect, including a large study employing a between-subject design and comprehensive behavioral assessment (Sayette et al., 2012) as well as a smaller pilot trial targeting Duchenne smiling behavior (Kirchner et al., 2006). Similar to effects reported in Sayette (2012), alcohol effects in the current study were unique to facial expressions linked with "felt" positive emotion, indicating effects uncovered here likely reflect emotional experience vs. simply broader alcohol-related behavioral activation. Notably, our study expands upon the results of Sayette et al. (2012) by employing both a within-subject design as well as comprehensive facial coding across the full period of social interaction. Although we found similar results to Sayette et al. (2012) regarding the relationship between alcohol and positive emotional expressions, we did not find support for relations between alcohol and FACS with respect to negative emotion, a result that echoes critiques raised in this area (Barrett et al., 2019). Our findings further indicated that effects of alcohol on facial expressions of emotion emerged as significant only in the latter stages of the consumption period; though this is consistent with the proposal that the pharmacological effects of alcohol would be strongest during this period (see Sayette et al., 2019), we note that the absence of a placebo condition prevents ruling out the potential impact of expectancy effects.

In the current study, alcohol demonstrated effects on Duchenne smiling above-and-beyond those observed via self-report, and thus these facial measures capture effects that would have been missed in a design relying solely on reported affect. These results suggest that present models of affect enhancement derived mainly from self-report might be *under*estimating the impact of alcohol on positive affect, thus complicating extant models regarding the role of emotion-related motives in shaping patterns of consumption and, ultimately, alcohol use disorder. At minimum, findings further indicate the importance of multi-modal assessments, suggesting that measures that move beyond introspection could be critical to capturing reinforcing effects of intoxicating substances.

Regarding our primary aims of examining the correspondence between self-report and facial displays of emotion, results indicated these measures were most strongly related in the control session yet tended to diverge when participants were intoxicated. Importantly, supplementary analyses ruled out both pro-social smiling behaviors and restricted positive emotional variability as potential competing explanations for observed relations. Considered together with a larger body of research documenting alcohol's tendency to disrupt processes involved in introspection and self-awareness, results bring to the fore questions surrounding links between cognitive capacity and cross-measure convergence. One possible explanation indicated by our findings is that alcohol disrupts individuals' ability to accurately distinguish and report their internal emotional states, thus interfering with the accuracy of measures of emotion based in self-report (Austin et al., 2020; Schmidt et al., 2013). Note, however, that the aim of the current research was to explore the question of *convergence* across methods for measuring emotion, not to directly examine the question of *accuracy;* we stress that we present neither self-report nor FACS results as the "true" indicator of emotion, and certainly one possible interpretation of the results of the present study is that divergence in emotion measurement findings represents a product of the fallibility of FACS as an emotional coding system. Indeed, the present study does not address the question of what emotions, if any, participants were "truly" feeling; this was not among its objectives, nor do the authors believe the methodology employed (or, at the extreme, *any* presently-available methodology) allows for such a claim. Nonetheless, when considered in light of both historical and more recent research in the field of emotion science, results might be interpreted as an incremental step towards understanding the broader utility and fallibility of systems for capturing affect.

Recent years have given rise to an increasing awareness of limitations associated with facial measures of emotion (Durán & Fernández-Dols, 2021; Gosselin et al., 2010). Some such accounts have gone so far as to suggest a broad lack of utility for systems of emotional measures that rely on facial action (e.g., Barrett et al., 2019). Yet others have suggested that wholesale dismissals of such facial measures on the basis of complex findings may suffer from the fallacy of the “perfect solution” (Haidt & Keltner, 1999). Self-report measures of affect—which represent far-and-away the most widely employed alternative to the facial index—offer a range of advantages in measuring emotional state and will doubtless remain a core tool in addiction science well into the future (Robinson & Clore, 2002). Research documenting the fallibility of such self-reports, however, might easily fill a football arena (Tournageau, 1984; Schwarz, 1999; Ward & Meade, 2023), suggesting that, among other things, results of these measures are difficult to interpret divorced from their context. Although offering little support for the notion of FACS as a true "window into the soul," as some early accounts might have suggested, results nonetheless point to FACS as one potentially useful tool for capturing the complex association between feeling and expression as they manifest across contexts.

Limitations

The present study should be interpreted in light of its limitations. First, study results are derived from a single standardized dose of alcohol, a limitation that resulted from practical experimental restrictions while also reflecting priority placed on the need for a robust experimental design featuring a no-alcohol control comparison condition. Future research should explore the extent to which results generalize across varying alcohol doses and rates of consumption. Additionally, the integration of a placebo condition may allow for disentangling expectancy vs. pharmacological effects with reference to influences on behaviorally expressed emotion, though we again note challenges in this area regarding interpretation of findings and preserving ecological validity (Testa et al., 2006; Fairbairn et al., 2015). Furthermore, in the current study, we opted to use umbrella measures of negative emotion (vs. measures that differentiate emotion subtypes). These umbrella measures were selected as the construct of primary focus within the broader addictions literature (e.g. Austin et al., 2020; Sayette et al., 2012). Nonetheless, as systems such as FACS have traditionally differentiated individual emotional states, future research might integrate self-report measures aimed at capturing discrete emotion subtypes, particularly those that demonstrate correspondence with social drinking behaviors both within the alcohol literature at large and in the context of self-report data collected within individual studies.

Furthermore, given restricted variability and overall low levels of negative affect observed in the present study, conclusions that can be drawn from the present negative emotion results are limited, and future research may benefit from experimental procedures that manipulate or induce negative emotion in a social drinking context to examine this variable more directly. Finally, while our sample size (N=60) was sizable in the context of within-subject design and sufficiently powered to address our current study objectives, future research might replicate findings among larger and more diverse samples of participants. Specifically, given that, in the present study, all participant groups contained individuals of the same gender and the vast majority were mixed-race in composition, future research may benefit from exploring the effects of alternative social group compositions, as differences in demographic variables and social identities are likely to influence the social environment and, consequently, the interactions that take place and emotions that are experienced within these contexts.

Conclusion

The present results contribute to the extant conversation regarding the utility and interpretability of facial measures of emotion by highlighting socio-contextual circumstances under which measures of emotion both converge and diverge. While this study may illuminate some aspects of the role of socio-contextual factors in shaping emotions, questions undoubtedly linger regarding the effect of settings and circumstances on affect as captured across measurement modalities. Future research should further explore these factors, moving beyond convergence to also capture questions of validity.

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Table 1. Means and intraclass correlation coefficients (ICCs) of emotion outcome measures

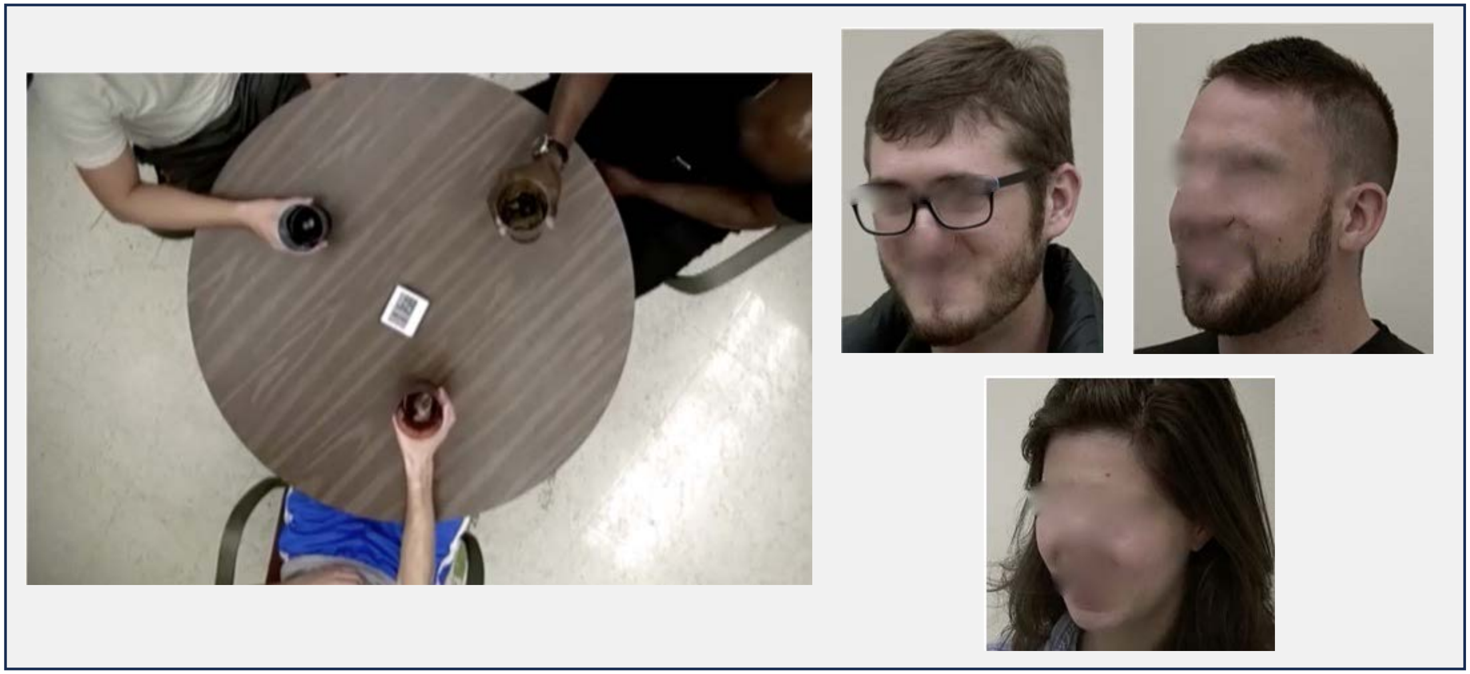
	Alcohol	Control	ICCs
FACS Results			
Duchenne	14.67 (*SD=11.60*)	13.37 (*SD=11.29*)	0.33
Social Smile	10.29 (*SD=7.44*)	9.91 (SD=7.34)	0.30
Negative Facial Expression	5.00 (*SD=4.50*)	5.91 (*SD=5.06*)	0.24
Self-Report Results			
Positive Affect	3.60 (SD=1.00)	2.83 (SD=1.10)	0.20
Negative Affect	0.20 (SD=.37)	0.57 (SD=.62)	0.25

Values presented above for facial displays of emotion are average seconds spent displaying each type of expression per minute of the 36-minute social interaction. Values presented above for self-report measures reflect average ratings on the post-drink 6-point Likert scale, summed across both indices of positive affect and indices of negative affect. Intraclass correlation coefficients (ICCs) between emotion outcome measures were calculated at the level of participants’ social groups.

Table 2. Full results of interactions between alcohol condition and post-drink self-report affect measures in predicting FACS

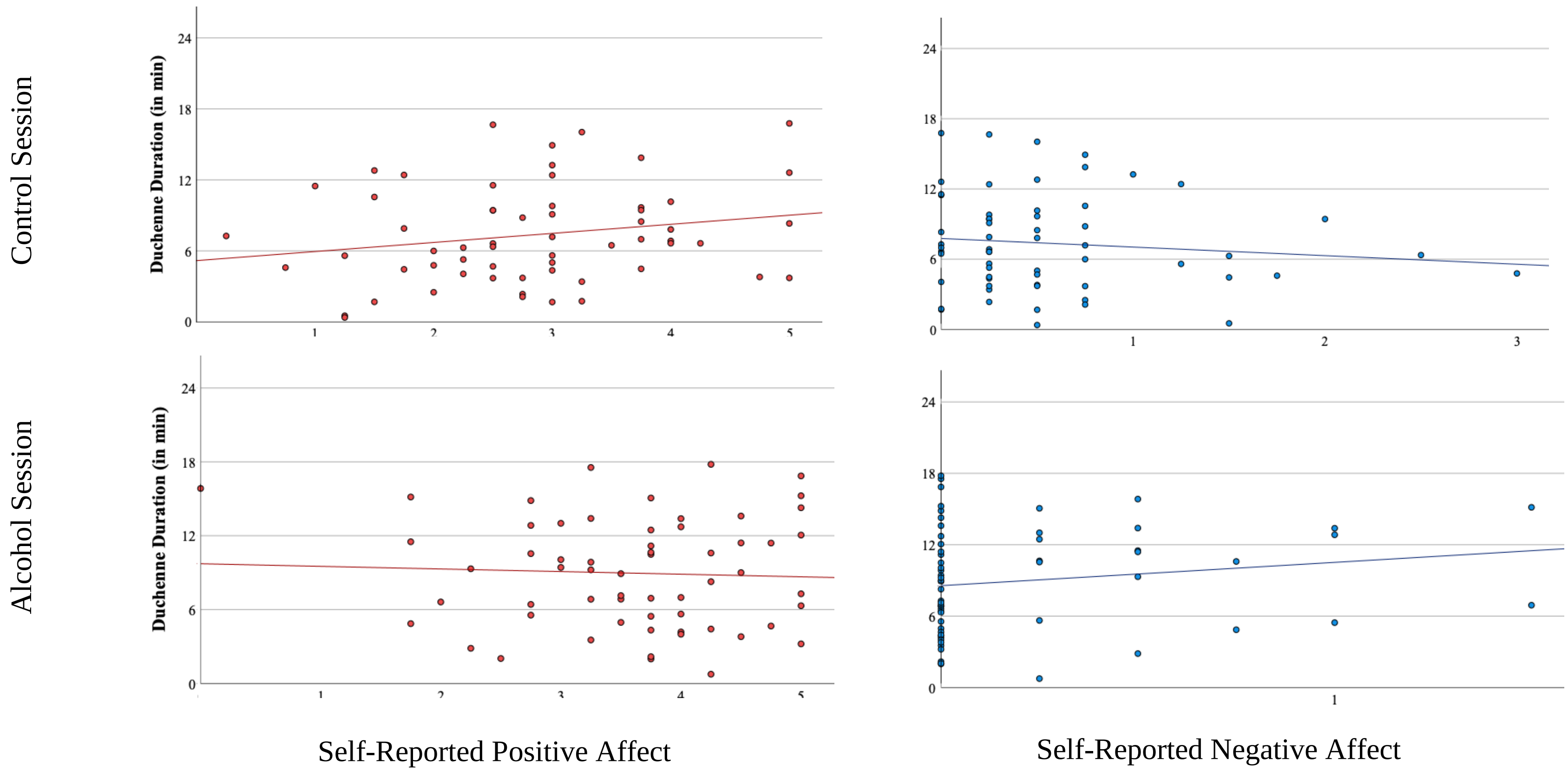
		Positive Affect		Negative Affect	
		Estimate	p-value	Estimate	p-value
Min 1-12	Duchenne	-0.172	0.0513	0.249	0.2579
	Social Smile	-0.037	0.5383	0.158	0.2856
	Negative Facial Expression	0.0480	0.4364	-0.087	0.5882
Min 13-24	Duchenne	-0.128	0.1280	**0.522**	**0.010**
	Social Smile	-0.047	0.460	-0.184	0.926
	Negative Facial Expression	-0.003	0.966	-0.029	0.862
Min 25-36	Duchenne	**0.079**	**0.001**	**0.477**	**0.019**
	Social Smile	-0.006	0.926	-0.184	0.281
	Negative Facial Expression	0.003	0.973	0.189	0.413
Overall (Min 1-36)	Duchenne	**-0.174**	**0.0216**	**0.432**	**0.021**
	Social Smile	-0.038	0.488	0.069	0.618
	Negative Facial Expression	0.012	0.859	0.064	0.697

Figure 1. Experimental procedures examples



Note: Three strangers were seated around a small circular table and were served either alcoholic or control drinks at 12-minute intervals throughout the course of the 36-minute social drinking interaction. Throughout the interaction, all participants were video recorded to facilitate FACS coding, and examples of participant facial expressions from across multiple participant groups are presented above. Participants depicted were taken from multiple groups and provided consent for recorded images to be disseminated via scientific publication, though images above are presented blurred to maintain participant confidentiality.

Figure 2. Significant interaction between self-reports and beverage session in predicting Duchenne smiling



In the above graphs, Duchenne smiling, aggregated at the level of the participant, is the outcome variable. Generalized linear models were used to account for non-normal outcome distribution. Although control session relations depicted above are significant (positive affect, *b*=0.146, *ERR*=1.157, t=2.48, *p*=0.015; negative affect, *b*=-0.201, *ERR*=0.818, t=-2.04, *p*=0.045), alcohol session relations are not (positive affect, *b*=-0.284, *ERR*=0.753, t=-0.44, *p*=0.656; negative affect, *b*=0.231, *ERR*=1.256, t=1.40, *p*=0.166).