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Alcohol and Emotional Contagion: An Examination of the Spreading of Smiles in Male and Female Drinking Groups

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Abstract
Researchers have hypothesized that men gain greater reward from alcohol than do women. However, alcohol-administration studies in which participants were tested when they were drinking alone have offered weak support for this hypothesis. Research has suggested that social processes may be implicated in gender differences in drinking patterns. We examined the impact of gender and alcohol on "emotional contagion"—a social mechanism central to bonding and cohesion. Social drinkers (360 male, 360 female) consumed alcohol, placebo, or control beverages in groups of three. Social interactions were videotaped, and both Duchenne and non-Duchenne smiling were continuously coded using the Facial Action Coding System. Results revealed that Duchenne smiling (but not non-Duchenne smiling) contagion correlated with self-reported reward and typical drinking patterns. Importantly, Duchenne smiles were significantly less "infectious" among sober male groups versus female groups and that alcohol eliminated these gender differences in smiling contagion. Findings identify new directions for research that explores social-reward processes in the etiology of alcohol problems.

Keywords
alcohol, gender, emotional contagion, facial mimicry, social context

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Individuals vary widely in their patterns of alcohol use, and researchers have long been interested in identifying individual difference criteria that reveal those at risk to develop alcohol-related problems (Sher, Grekin, & Williams, 2005). In the search to identify predictors of alcohol-abuse susceptibility, few individual difference criteria have demonstrated as powerful a relationship with problematic drinking as has gender. Men show dramatically higher rates of alcohol-related problems than do women. Men are 50% more likely than women to binge drink and twice as likely to report symptoms of alcohol abuse and dependence (Substance Abuse and Mental Health Services Administration, 2012).

A long-standing hypothesis among alcohol researchers is that gender differences in susceptibility to alcohol-use disorder may be traced to gender differences in alcohol-reward sensitivity (Nolen-Hoeksema, 2004). According to this hypothesis, men would be expected to experience more subjective reinforcement from drinking alcohol than would women (Sher, 1987; Wilson, 1988). Importantly, laboratory-based studies that have investigated gender differences in alcohol-related reinforcement have not produced consistent findings. Although a handful of alcohol-administration studies have reported significant gender differences (Dougherty, Bjork, & Bennett, 1998; Mills & Bisgrove, 1983; Niaura, Nathan, Frankenstein, Shapiro, & Brick, 1987), many studies have not shown

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significant differences across gender in response to alcohol consumption (e.g., Breslin, Mayward, & Baum, 1994; Josephs & Steele, 1990; Levenson, Oyama, & Meek, 1987; Mulvihill, Skilling, & Vogel-Sprott, 1997; Sayette, Breslin, Wilson, & Rosenblum, 1994; Sayette, Martin, Perrott, Wertz, & Hufford, 2001; Steele & Josephs, 1988). A variety of methodological factors may have contributed to these inconsistent findings, including lack of statistical power in many studies and a tendency to focus on self-report measures of mood.

One explanation for inconsistent effects of gender in the alcohol-administration literature is a failure to incorporate social context into experimental paradigms. Participants in laboratory-based alcohol studies tend to consume their study beverages in an isolated setting, with no other individual present in the room. These asocial-drinking environments are likely poorly suited to an examination of differences according to gender. On the basis of decades of research on patterns of gender differences across a variety of contexts, researchers have moved away from a static conceptualization of gender as a trait that predicts outcomes with equal regularity across settings (Wood & Eagly, 2010). Instead, gender is seen as a set of biological and societally determined predispositions that emerge selectively and dependent on elements of the proximal environment (Goffman, 1959). Importantly, researchers have observed only small and inconsistent gender differences along nonsocial outcomes (e.g., measures of verbal and quantitative ability) but dramatic differences between men and women when behavioral and emotional responses are observed in a social context (Eagly, 1995; Maccoby, 1990). Thus, theorists have identified "social interaction" as the context in which "the enactment of gender primarily takes place" (Deaux & Major, 1987, p. 370).

Several lines of alcohol research also have suggested that social-drinking paradigms could inform the understanding of gender differences in drinking patterns. Among both men and women, the overwhelming majority of drinking outside the laboratory occurs within the context of social interaction (Cahalan, Cisin, & Crossley, 1969; Demers et al., 2002; Single & Wortley, 1993; see Fairbairn & Sayette, in press). The formation and maintenance of social bonds has been identified as a fundamental human motive (Baumeister & Leary, 1995), and social factors exert considerable influence over emotions and behaviors. Across all drinking motives, social-enhancement motives show the most powerful and consistent differences according to gender, with men drinking more to enhance social situations than do women (e.g., Cooper, 1994; see Kuntsche, Knibbe, Gmel, & Engels, 2006), and studies on social alcohol expectancies have shown similar gender effects (e.g., Rohsenow, 1983; see Wilson, 1988, for a review). All-male drinking groups and all-male societies often show particularly high rates of hazardous drinking (Bartholow, Sher, & Krull, 2003; Bot, Engels, & Knibbe, 2005; Senchak, Leonard, & Greene, 1998; although see Rosenbluth, Nathan, & Lawson, 1978), and social factors may be more related to problematic drinking among men than among women (e.g., Mooney, Fromme, Kivlahan, & Marlatt, 1987). In sum, social environments are important in the study of problem drinking, and social factors may be implicated in gender differences in alcohol-use disorders.

Gender, Social Bonding, and Emotional Contagion

A factor that differs dramatically across gender is the tendency to engage in intimacy-building behaviors during social interactions. Although research does not support the premise that men are less motivated than women to create close social relationships (Baumeister & Sommer, 1997), men display fewer affiliative behaviors during social interaction (Eagly & Wood, 1991). Socioculturally defined gender roles are generally inconsistent with high levels of intimacy and affiliation displays among men and instead promote displays of male competency and status (Briton & Hall, 1995; Deaux & LaFrance, 1998). Accordingly, research has suggested that men are constrained in their displays of intimacy-building behaviors and demonstrate lower levels of social skill in affiliative social contexts. Compared with women, men smile less during social interaction (LaFrance, Hecht, & Paluck, 2003), self-disclose less (Dindia & Allen, 1992), and demonstrate poorer emotion encoding (Hall, Coats, & LeBeau, 2005) and decoding abilities (Hall, 1978; McClure, 2000). Women show more responsiveness to the needs of others in close social relationships and offer more appropriate social support than do men (Cultrona, 1996; Neff & Karney, 2005). As men and women age from adolescence into adulthood, women benefit from larger and more supportive social networks (Antonucci & Akiyama, 1987). Thus, compared with women, men may not always feel free to engage social intimacy-building behaviors, and researchers have suggested that such constraints might carry negative consequences for their close social relationships (Baumeister & Sommer, 1997).

Emotional contagion[1] is an important mechanism through which feelings of affiliation and social connectedness are generated during social interaction (Chartrand & Lakin, 2013; Hatfield, Cacioppo, & Rapson, 1993; Hess & Fischer, 2013). In social contexts, individuals unconsciously mimic the nonverbal expressions of their interaction partners and thereby "catch" their emotional states (Hatfield et al., 1993). Referred to by researchers as "social glue" (Lakin, Jefferis, Cheng, & Chartrand, 2003), emotional mimicry has been implicated in a variety of critical intimacy-building processes, including accurate decoding of emotional states of interaction partners (Niedenthal, 2007; Oberman, Winkielman, & Ramachandran, 2007; Stel & van Knippenberg, 2008). Individuals instructed to mimic the behaviors of their interaction partners report experiencing a more positive social experience (e.g., Stel & Vonk, 2010), and the relationship between emotional mimicry and social intimacy may be especially strong when smiling is the behavior being mimicked (Hess & Fischer, 2013).

Although emotional contagion is common in social interaction, automatic mimicry responses may sometimes be inhibited (Chartrand & Lakin, 2013). For example, concerns with maintaining social status and perceived competence may constrain displays of mimicry (Kavanagh, Suhler, Churchland, & Winkielman, 2011; Lanzetta & Englis, 1989; Tiedens & Fragale, 2003). Men are less likely to mimic emotional expressions than are women, and research has suggested that controlled inhibition of mimicry among men may account for these gender differences (Dimberg & Lundquist, 1990; Hatfield, Cacioppo, & Rapson, 1992; Sonnby-Borgstrom, Jönsson, & Svensson, 2008). Experimental manipulations that reduce controlled inhibitive resources may sometimes facilitate the expression of emotional mimicry (van Leeuwen, van Baaren, Martin, Dijksterhuis, & Bekkering, 2009). A manipulation that has reliably impaired limited-capacity control processes is alcohol consumption (e.g., Fillmore, Vogel-Sprott, & Gavrilescu, 1999; Kirchner & Sayette, 2003; Steele & Josephs, 1990).

The Current Study

The current study is the first to our knowledge to test the impact of gender and alcohol consumption on emotional contagion. The data set we used to examine this question has significant methodological advantages over prior studies of the effects of gender on alcohol response. First, participants in our study drank alcohol in a social context, a setting that is especially appropriate for an examination of gender differences (Deaux & Major, 1987). Second, unlike many prior studies of gender differences in alcohol response, the current study included both placebo and control comparison groups. In light of suggestions by researchers that men and women differ in their expectancies for alcohol-based reinforcement (Sher, 1987; Wilson, 1988), the ability to parse pharmacological from expectancy effects of alcohol represents a significant advantage.[2] And, third, during the social-drinking period, facial muscle movements associated with smiling were continuously and unobtrusively assessed using the Facial Action Coding System (FACS; Ekman, Friesen, & Hager, 2002). FACS is the most sophisticated and comprehensive system for coding facial expression and serves as an objective and reliable measure of emotional state (Ekman & Rosenberg, 2005). For the present study, we focused on the most widely studied emotion-related expression in FACS, the Duchenne smile (e.g., Ekman, Davidson, & Friesen, 1990; Hess, Banse, & Kappas, 1995; Kirchner, Sayette, Cohn, Moreland, & Levine, 2006). Unlike other types of smiles, Duchenne smiles have been associated with "felt" rather than "displayed" emotion (Ekman & Rosenberg, 2005).

To assess emotional contagion in our group drinking setting, we applied state-of-the-science statistical procedures capable of modeling dynamic social processes (Aalen, Borgan, & Gjessing, 2008). In an initial set of analyses, we examined the interaction of alcohol and gender by counting the number of video frames in which all three members of a group smiled simultaneously (a group smile) during a social exchange (Sayette, Creswell, et al., 2012). Using this approach, we found that although both female gender and alcohol consumption were linked to higher levels of group smiling, alcohol did not interact with gender. These initial analyses provide a good starting place to examine alcohol's social effects. Importantly however, the static approach to behavioral assessment we used in Sayette, Creswell, et al. (2012) could not address emotional contagion or the study of social coordination more generally. In particular, the group-level outcome in Sayette, Creswell, et al. did not permit examination of factors that vary within groups, such as gender. Accordingly, our initial analysis could not distinguish the effects of being a woman from that of being in a group with women. In addition, our analytic approach did not model the sequence of individual-level events that preceded a group smile. Thus, group smiles that erupt almost instantaneously, sparked by any fleeting smile from an individual group member, are treated identically to group smiles that are drawn forth only after repeated or prolonged individual smiles.

In the current study, we apply a statistical approach that, although rarely implemented within behavioral research, is nonetheless ideal for studying social interaction (Gardner & Griffin, 1989; Griffin & Gardner, 1989; Stoolmiller & Snyder, 2006). Here, we model smiling using multilevel survival analysis, following the spread of smiles from one individual group member to the next. We focus on the simultaneous smile or mutual smile as a form of social coordination that carries important implications for social reward (Kirchner et al., 2006; Sayette, Creswell, et al., 2012). More specifically, we use survival analysis to examine the likelihood that a smile initiated by a single group member will (a) progress into a smile shared with another group member (a "mutual smile") versus (b) end without evoking a responding smile (an "unreciprocated" smile). Unlike many commonly used behavioral analytic strategies (Bakeman & Gottman, 1997), survival analysis models not only the sequential ordering of behaviors but also their temporal duration and relative timing. Researchers have argued that a consideration of the relative timing of events is central to the study of emotional mimicry during unstructured interaction and also to the broader study of contagious processes (Diggle, 2006; Hove & Risen, 2009; Scheel, Aldrin, Frigessi, & Jansen, 2007). Our use of survival analyses allows us to ask a range of questions not possible using other approaches commonly applied to the study of social coordination, including (a) Are the effects of alcohol and gender on mutual smiling related to increases in the duration of initial smile or, instead, truly attributable to increases in social responsiveness? (b) Are effects constant across the duration of the initial smile, that is, do they arise immediately or only after a delay? and (c) What is the effect of the smile initiator's gender versus the gender of the smile initiator's group-mates? In this article, we examine these and other related issues, including the potential implications of "catching" a smile for social reward and typical drinking patterns.

We had two primary objectives in the present study. First, we aimed to use dynamic emotional assessment to examine the main effect of alcohol consumption on emotional contagion in a group drinking setting. Findings reported in our initial study (Sayette, Creswell, et al., 2012) suggested that alcohol increased incidence of simultaneous smiling but left unanswered questions about potential mechanisms that might underlie these social effects (e.g., emotional contagion vs. individual-level processes). Second, we aimed to examine whether alcohol and gender interacted to predict the contagiousness of smiles. We hypothesized that gender differences in alcohol-related reinforcement would emerge. Specifically, we predicted that drinking alcohol would be associated with greater reward among men than among women and that this reward would manifest selectively as a social, catching process. Accordingly, we predicted that among sober groups, smiles would be less contagious in interactions that contained more men than women and that alcohol consumption would especially free men to engage in intimacy-building behaviors and catch the smiles of fellow group members. Thus, we predicted that alcohol would increase the contagiousness of smiles to a greater extent among men than among women in our social-drinking setting.

Method

Participants

As detailed elsewhere (Sayette, Creswell, et al., 2012), participants consisted of 720 healthy social drinkers, aged 21 to 28, recruited via advertisements in local newspapers. Of these participants, 360 were male and 360 were female. Individuals who successfully completed an initial phone interview were invited to the Alcohol and Smoking Research Laboratory for a screening session. After informed consent was obtained, exclusion criteria were assessed. Exclusion criteria included medical conditions that contraindicated alcohol consumption; past alcohol abuse or dependence, as indexed by the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994); pregnancy in females; not being within 15% of ideal weight for height; and being uncomfortable with study drinking requirements. Eligible participants were invited to participate in the experiment (83% European American, 11% African American, 1% Hispanic, 2.5% Asian, and 2.5% other). Participants reported drinking two to three times per week and consuming 4.29 (*SD* = 1.89) drinks per occasion.

Procedure

Participants were informed that the purpose of the study was to measure alcohol's impact on cognitive performance. They were randomly assigned to groups of three, and groups were then assigned to an alcohol-beverage (told alcohol, received alcohol), a placebo-beverage (told alcohol, received no alcohol), or a control-beverage (told no alcohol, received no alcohol) condition. Within each of the three beverage conditions, groups were evenly distributed according to gender composition. Specifically, each beverage condition contained 20 all-female groups, 20 all-male groups, 20 groups with two females and one male, and 20 groups with two males and one female. On their arrival in the lab, participants were casually and individually introduced to confirm that they were not previously acquainted (Kirchner et al., 2006). Additional participants were invited to each session to ensure that the 3 selected participants were unacquainted (see Sayette, Creswell, et al., 2012). Participants then provided a breath sample to assess blood alcohol concentration (BAC) and completed a variety of self-report mood and personality assessments.

The 3 participants were next seated at equidistant intervals around a round table. Cameras were positioned in all four corners of the room, and a microphone recorded conversation. Participants were originally told that the cameras were used to monitor their drink consumption and were later informed that the cameras recorded facial expressions.

Participants in the alcohol and placebo conditions were informed that they would be receiving alcohol and that the dose would be less than the legal driving limit. Drinks were mixed in front of all study groups (Rohsenow & Marlatt, 1981). The alcoholic beverage was 1 part

100-proof vodka and 3.5 parts Ocean Spray Cranberry Juice Cocktail. In the placebo group, the glass was smeared with vodka, and a few drops of vodka were "floated" on the top of the beverage to increase credibility. We accounted for differences between men and women in rates of alcohol metabolism by adjusting the dose of alcohol according to gender. Males in the alcohol condition were administered a 0.82-g/kg dose of alcohol, whereas females were administered a 0.74-g/kg dose (Sayette et al., 2001). Participants remained seated for a total of 36 min while beverages were administered in three equal parts at 0 min, 12 min, and 24 min. They were instructed to drink their beverages evenly during the 12-min intervals and refrain from discussing how intoxicated they felt. Participants were otherwise not given instructions relevant to the social interaction—participants were ostensibly seated in the same room to facilitate drink administration and communication with the experimenter.

Immediately after the drinking period, we recorded participants' BACs and had them complete measures of mood and social bonding. Next, they performed some additional cognitive tasks (see Sayette, Dimoff, Levine, Moreland, & Votruba-Drzal, 2012). After BAC was again assessed, placebo and control participants were debriefed, paid $60, and allowed to leave. Participants in the alcohol condition remained until their BACs dropped below 0.025%. Before leaving, participants were informed that their behavior had been videotaped, and their consent to analyze the data was solicited (all participants agreed).

Participants' facial expressions during the drinking period were later coded by FACS-certified personnel using Observer Video-Pro software (Noldus Information Technology, 2010). The Observer system allows coders to time-stamp the start (onset) and stop (offset) of each facial muscle movement or action unit (AU) to preserve the flow and synchrony of the interaction. Each frame (1/30th of a second) of the interaction was manually evaluated by coders for the presence or absence of relevant facial AUs. Coders were blind to experimental condition. Video from each participant was independently coded so that the facial expressions of only one group member were visible to the coder at one time.

Measures

Typical drinking patterns. During their initial laboratory screening session, participants provided information concerning their typical drinking patterns. Specifically, they answered questions regarding the frequency of their alcohol use during the past 30 days (occasions per week) and the average amount of alcohol (number of drinks) they consumed per drinking occasion.

Behavioral-affective display. We indexed felt emotional experience during the social interaction using the Duchenne smile (Ekman et al., 2002). Duchenne smiles include combined movement of the zygomaticus major muscle (AU 12) and the obicularis oculi muscle (AU 6; Ambadar, Cohn, & Reed, 2009; Ekman et al., 1990). Displayed emotion was indexed using the non-Duchenne smile—the movement of AU 12 alone without the movement of AU 6. Coders showed excellent interrater agreement for smiling (AU 12: $\kappa = .84$; AU 6: $\kappa = .88$).

Self-reported reward. As in our past research (Fairbairn & Sayette, 2013), we indexed reward using self-report measures of mood and social bonding administered immediately after the interaction. We assessed social bonding using the Perceived Group Reinforcement Scale. We assessed positive and negative mood using an eight-item mood measure (see Fairbairn & Sayette, 2013, for more details).

Data analysis

Data processing. Data were coded continuously throughout the 36-min interaction with the exception of Minutes 3 through 11 (only 29% of groups coded) and an additional 2 min during which the experimenter entered the room to refill drinks. As before, we examined data from Minutes 12 through 36 of the interaction—the period in which the effects of alcohol were hypothesized to be the strongest (Sayette, Creswell, et al., 2012). Approximately 34.9 million frames of behavioral data were coded. One group was excluded from analysis for technical reasons.

Beverage condition. Beverage condition was initially represented as a complete orthogonal set of contrast codes, the first ("alcohol") contrast compared the alcohol condition with both the placebo and the control conditions, and the second ("placebo vs. control") contrast compared the placebo and control conditions (Cohen, Cohen, West, & Aiken, 2003). After confirming that there was empirical justification for collapsing across placebo and control conditions in these analyses (lack of significance of the placebo vs. control contrast), we represent alcohol condition as a single dummy code.

Overview and objectives. We aim to model the spread of smiles from one group member to the next by following smiles displayed by a single group member as they develop into smiles that are shared with other group members. To avoid redundancies within statistical models, we focus on smiles first initiated when no other group member is currently smiling. Given research that has highlighted the importance of timing in emotional

Table 1. Beverage Manipulation Check

Measure	Alcohol	Placebo	Control	F
BAC after drinking	0.055_a (0.012)	0.001_b (0.001)	0.001_b (0.001)	4,825.72**
BAC 40 min after drinking[a]	0.062_a (0.011)	0.001_b (0.001)	—	7,116.15**
SIS after drinking	38.50_a (17.31)	14.90_b (10.44)	0.20_c (1.49)	647.70**
SIS 40 min after drinking[a]	35.12_a (16.90)	8.90_b (10.80)	—	410.12**
Highest intoxication	43.53_a (18.71)	16.15_b (11.11)	0.61_c (3.19)	698.07**
Vodka estimate (ounces)	7.11_a (9.85)	4.64_b (5.44)	0.05_c (0.43)	70.80**

Note: The table presents means for each measure. Standard deviations are shown in parentheses. SIS and highest intoxication were scored on scales ranging from 0 to 100. Within each row, values with different subscripts are significantly different ($p < .05$). BAC = blood alcohol concentration; SIS = Subjective Intoxication Scale.
[a]Control participants were not asked to provide these data.
**$p < .001$.

contagion and mimicry processes, we use the word *infectiousness* in this article in reference only to results of models that consider duration of the initial smile (i.e., survival analyses).

Many of the analyses implemented within this article are well established within science but rarely applied within psychology (e.g., three-level nested frailty models). We therefore move through our analyses in stages by beginning with the most simple and intuitive models and progressing through analytic approaches that increase in level of statistical complexity. As we arrive at each new stage in our analysis, we present a question that was left unanswered by previous (often more commonly implemented) statistical models together with a rationale for the next "stage" in our analysis. Specific information about data analytic strategies is presented immediately prior to the results produced by these models. Our analysis begins with simple event sequences at the level of the group and ends with models that examine within-groups predictors and incorporate a complex consideration of event duration.

Results

Beverage manipulation check and baseline comparisons

BACs and measures of subjective intoxication are presented in Table 1. Participants assigned to drink alcohol were on the rising limb of the BAC curve with a BAC of just above 0.06% immediately following the interaction period. All participants assigned to the placebo and alcohol conditions estimated that they had consumed at least 1 oz of vodka. Consistent with our prior studies (e.g., Sayette et al., 2001), results showed that participants in the placebo condition reported experiencing some level of intoxication (more than participants in the control condition and less than participants in the alcohol condition). Neither gender nor typical drinking patterns significantly affected BACs or subjective levels of intoxication. As reported elsewhere, there were no differences in baseline personality or mood variables across beverage conditions (see Sayette, Creswell, et al., 2012).

Event-level analysis

We begin by exploring the spreading of smiles within groups at the level of the "event." In other words, we test the probability of a single smile developing into a mutual smile (vs. an unreciprocated smile) without considering the duration of smiles under examination. Consistent with the notion that alcohol enhances social bonding, event probabilities displayed in Table 2 suggest that smiles initiated in groups that consumed alcohol were more likely to lead to mutual smiles (49.6%) than were smiles initiated in the placebo (45.6%) or control (44.6%) conditions, with the latter two conditions not differing. Furthermore, irrespective of beverage condition, smiles initiated in groups that consisted of all males were less likely to develop into mutual smiles (42.6%) than were smiles initiated in all-female groups (48.6%). Finally, a glance at these descriptive statistics suggests that the effect of alcohol on increasing transitions to mutual smiles may be larger in groups containing more males. Hierarchical logistic regression models (Kenny, Kashy, & Cook, 2006; Raudenbush & Bryk, 2002) confirm many of these observations. Alcohol significantly increased the likelihood that a smile would develop into a mutual smile, $B = 0.219$, odds ratio (OR) = 1.245, $t = 3.260$, $p = .001$, as did the number of women included in the group, $B = 0.092$, $OR = 1.096$, $t = 3.160$, $p = .002$. Moreover, there was a marginally significant Alcohol Condition × Group Gender Composition interaction, $B = -0.116$, $OR = 0.890$, $t = -1.920$, $p = .055$, thereby suggesting that this main effect of alcohol was driven by its effects on men. The distinction between placebo and control conditions did not emerge as significant in any analysis (ps > .8).

Table 2. Percentage of Smiles That Led to a Mutual Smile

Group gender composition	Alcohol	Placebo	Control	Total
All male	50.4 (614)	37.4 (321)	38.2 (434)	42.6 (1,369)
2 males and 1 female	48.8 (780)	44.4 (490)	45.7 (651)	46.5 (1,921)
1 male and 2 females	49.8 (714)	49.1 (683)	45.7 (558)	48.4 (1,955)
All female	49.4 (822)	48.2 (679)	47.9 (659)	48.6 (2,160)
Total	49.6 (2,930)	45.6 (2,173)	44.6 (2,302)	46.8 (7,405)

Note: The table presents percentage of initial smiles that led to a smile that was shared with another group member (vs. ended without eliciting a responding smile). Cell counts are shown in parentheses. Note that percentages are not intended to sum to 100%, given that nonreciprocated smiles are not represented within the table.

Survival analysis

The event-level analysis described in the preceding section provides a useful starting point in our examination of social coordination. Unlike analyses implemented in our previous work (Sayette, Creswell, et al., 2012), this event-level approach considers the sequencing of smiles within groups, thereby accounting for not only the number of mutual smiles displayed during the social interaction but also the number of individual smiles that were left unreciprocated. Analyses that focus on social interactions as sequences of events represent the single most popular framework for the examination of social exchange (e.g., sequential analysis; Bakeman & Gottman, 1997). It is important to note, however, that this event-level approach ignores a substantial amount of valuable information contained in the data. An event-level analysis does not consider the duration of the behavior under examination. A smile that develops into a mutual smile after 0.2 s, for example, is treated identically to a smile that develops into a mutual smile after 8 s (Griffin & Gardner, 1989). In the current study, as is increasingly common in studies of social interaction, data were not collected at the level of the event; instead, behavior was continuously coded in time, which produced a data set so precise as to carry information down to the level of the frame (1/30th of a second). Effectively "throwing out" event-duration information might in some cases undermine power to detect significant effects (Green & Symons, 1983). Furthermore, a behavior displayed during a prolonged period may have different effects than this same behavior displayed only fleetingly (Ekman, 2009); therefore, depending on the theoretical focus of the study, a strictly event-level analysis may lead to misconceptions concerning the nature of the social process under examination.

Given the focus on contagious processes in the current project, concluding our analysis at the level of the event seems to pose problems. In any examination in which researchers seek to determine the level of infectiousness of a given agent, information concerning intensity of exposure to the proposed pathogen is highly relevant (Diggle, 2006; Diggle, Heagerty, Liang, & Zeger, 1994; Scheel et al., 2007). Of particular note, in the current study, smiles in the alcohol condition lasted on average 1 s longer (4.5 s) than did smiles in the no-alcohol conditions (placebo: 3.47 s; control: 3.48 s), $B = 1.048$, $t = 6.99$, $p < .0001$. Thus, any main effects or interactions involving alcohol could potentially have emerged as a result of these increased smile durations. In other words, we might observe increases in mutual smiling with alcohol not because alcohol increases the innate infectiousness of smiles per unit time but because exposure to the initial smile was more prolonged.

In contrast to event-focused approaches, survival analysis considers not only the sequence of events but also the event duration (Gardner & Griffin, 1989; Griffin & Gardner, 1989; Stoolmiller & Snyder, 2006). The quantity that is studied within a survival framework is the "hazard" or the probability of a given outcome occurring per unit time under examination. In the results reported in the following section, the hazard is represented by the abbreviation Exp(B) and can be interpreted as a form of "relative risk" across levels of the predictors. At this stage of our analysis, we employed a "competing-risks" frailty survival model to account for clustering of recurrent events at the level of the group (Allison, 2012).

Results of survival models

Group gender composition significantly affected the hazard of a smile developing into a mutual smile, $B = 0.088$, Exp(B) = 1.092, $SE(B) = 0.022$, $p < .0001$. Introducing each woman into a group resulted in a 9.2% increase in transitions into mutual smiles per unit time that the initial smile was displayed (see Fig. 1 for cumulative hazard results across group gender composition). In contrast to the event-level analysis presented earlier, however, the survival model produced no significant main effect of alcohol ($p = .712$). Accounting for each unit time that a smile was displayed, we found that there was no main effect of alcohol on the probability that a smile would develop into a mutual smile. When considered together

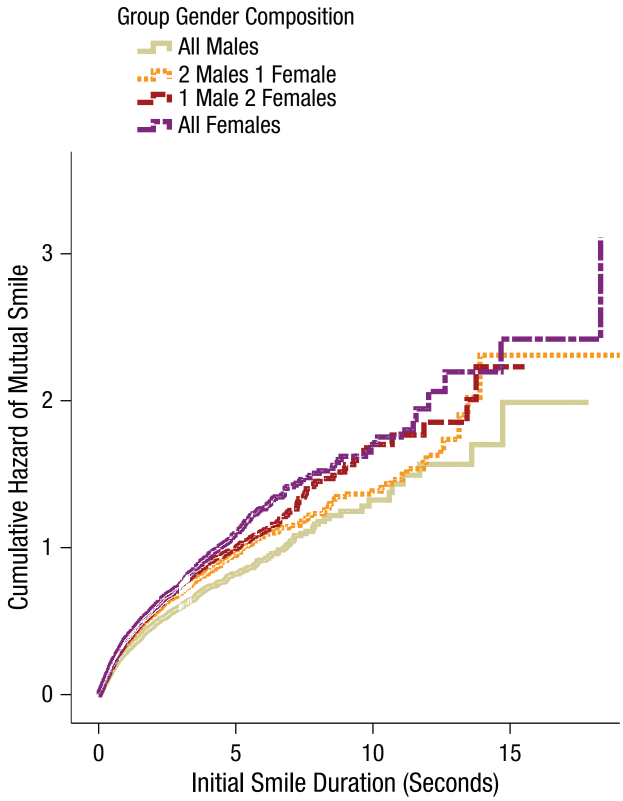

Fig. 1. Results: cumulative hazard of a smile developing into a mutual smile across group gender composition.

with prior analyses, these results suggest that broad alcohol-related increases in mutual smiling are attributable to alcohol's tendency to prolong the duration of individual (initial) smiles. Survival analysis revealed that per unit time that the initial smile was displayed, alcohol had no impact on the likelihood that the initial smile would be reciprocated.

Importantly, the effect of alcohol on mutual-smile hazard varied depending on group gender composition. Alcohol significantly increased the contagiousness of smiles selectively among all-male groups. Survival models indicated a significant Alcohol Condition × Group Gender Composition interaction, B = –0.109, Exp(B) = 0.897, SE(B) = 0.045, p = .015. Alcohol did not significantly increase the hazard of transition to mutual smiling when groups contained any women. In contrast, we found that alcohol was associated with an increase in hazard of transition to mutual smiling among groups consisting of all males. When groups comprised only men, alcohol was associated with an increase of 21% in transitions to mutual smiling per unit time that the initial smile was displayed, B = 0.192, Exp(B) = 1.211, SE(B) = 0.086, p = .025. Thus, selectively among all-male groups, alcohol-related increases in mutual smiling were not solely attributable to increased initial-smile duration. Sober all-male groups showed significantly fewer mutual-smile transitions when compared with sober groups that contained women, B = –0.128, Exp(B) = 0.879, SE(B) = 0.027, p < .0001, and alcohol eliminated this male deficit in mutual-smiling hazard. Again, we found no significant distinction between placebo and control conditions in any of these analyses (ps > .42).

Is this really contagion?

Thus far in our analyses, we have considered only situations in which one group member has already initiated a smile. We have not considered situations in which no group members are currently smiling. If the interaction between gender and alcohol identified earlier manifests as a result of a purely "contagious" process, passed from one group member to the next, we would expect this interaction to emerge selectively in situations when one group member has initiated a smile. Results reported to this point do not rule out the possibility that the outcome we refer to as smile "contagiousness" reflects predilection to smile, regardless of whether another group member is already smiling.

To address this question, we examined whether the interaction between alcohol and gender emerged to predict smiling hazard in situations in which no other group members are currently smiling ("noninfection" model). Results derived from this noninfection model can then be compared with results produced by the infection models reported earlier, which considered situations in which another group member is already smiling. In this case, we constructed two separate models to allow the shape of the hazard to vary across these distinct situations. It is important that within the noninfection framework, the Alcohol Condition × Group Gender Composition interaction does not approach significance, B = 0.002, Exp(B) = 1.002, SE(B) = 0.047, p = .960. Thus, it appears that alcohol's tendency to increase mutual smiling selectively in all-male groups is not explained by overall increases in smiling and, instead, appears more similar to a contagious process that manifests on exposure to a smile from another group member.

Do results vary across smile duration?

A unique aspect of survival analysis is its capability for addressing sophisticated hypotheses concerning the effect of variations in event timing on hazards (Allison, 2012). Within psychology, information concerning whether an effect emerges instantaneously versus after a delay can explicate the mechanisms underlying this process (e.g., automatic vs. controlled; Greenwald, McGhee, & Schwartz, 1998). Here, we explored whether effects of gender and alcohol on transitions to mutual smiling varied as a function of the time after onset of the initial smile. We uncovered a significant Group Gender Composition × Alcohol Condition × Smile Duration interaction, $B = -0.041$, Exp(B) = 0.960, $SE(B) = 0.018$, $p = .023$. Among groups that did not consume alcohol, there was a significant Smile Duration × Group Gender Composition interaction, $B = 0.027$, Exp(B) = 1.028, $SE(B) = 0.012$, $p = .019$. Sober groups showed similar rates of transition to mutual smiles in an instantaneous or immediate fashion regardless of gender composition, but after a delay, sober all-male groups showed lower hazards to mutual smile than did groups that contained more females. Alcohol acted to eliminate this deficit for males in noninstantaneous (delayed) mutual-smile hazard ($p = .986$).

Moving beyond the group

To this point, our analyses have been conducted strictly at the level of the group. However, unlike analyses implemented in many previous studies of behavioral coordination (e.g., Sayette, Creswell, et al., 2012), survival analysis allows for the differentiation of the individuals acting within each group. Specifically, we can disentangle the effects of the gender of the individual who initiated the smile from the gender of this individual's group-mates. Thus, using Kenny and Garcia's (2012) actor-partner interdependence model, we sought to differentiate the effects of being a man from the effects of being in a group with men on hazard to mutual smiling.

Applications of survival analysis to social interaction have not previously moved beyond the level of the group, thereby accounting for nesting at only two levels of analysis—within-groups and between-groups (Stoolmiller & Snyder, 2006). However, the three-level (nested) frailty model has been well studied in fields outside of psychology, and software is now readily available for implementing such analyses (Sastry, 1997; Therneau, 2011). We conducted a nested frailty model within the R software program coxme (Therneau, 2011). Results indicated that the gender of the individual who initiates the smile does not affect the hazard that a smile will transition into a mutual smile. In other words, we did not find evidence that smiles displayed by women are more infectious, and we found no moderating influence of alcohol on this effect (ps > .52). Instead, the group-level gender-composition effects outlined earlier appear to be driven by the gender of the smile initiator's group-mates (potential smile responders). Hazard to mutual smile was 23% lower if smiles were initiated in groups with two male group-mates versus groups with one or two female group-mates, $B = -0.257$, Exp(B) = 0.773, $SE(B) = 0.048$, $p < .0001$. If the smile initiator's group-mates included at least one female, then hazard to mutual smile reached equivalent levels to those observed in groups including two female group-mates ($p = .18$).

Finally, there was a highly significant interaction between group-mates' gender and alcohol condition, $B = 0.373$, Exp(B) = 1.452, $SE(B) = 0.098$, $p = .0001$. When both group-mates were men, alcohol increased the hazard of a smile developing into a mutual smile by 30%, $B = 0.263$, Exp(B) = 1.302, $SE(B) = 0.083$, $p = .002$ (see Fig. 2 for cumulative hazard results as a function of beverage condition and gender of group-mates). In contrast, there was no significant effect of alcohol on hazard to mutual smiles when at least one group-mate was a female. These results suggest that alcohol selectively boosts the chances that men will catch a smile and may have comparatively little effect on smile infection passed to women.

Clinical and reward implications (What does it mean to catch a smile?)

We next examined the potential implications of smile infection for alcohol-related reward and reinforcement value. First, we explored the relationship between smile infectiousness and reward by examining associations between mutual-smile hazard and self-reported indexes of mood and social bonding administered after the interaction. Similar to gender findings reported earlier, effects emerged primarily in models that considered attributes of the smile initiator's group-mates. Specifically, increased probability of smile catching corresponded to significant increases in positive mood, $B = 0.065$, Exp(B) = 1.067, $SE(B) = 0.019$, $p = .0005$, and social bonding, $B = 0.023$, Exp(B) = 1.023, $SE(B) = 0.011$, $p = .046$, together with decreases in negative mood, $B = -0.095$, Exp(B) = 0.909, $SE(B) = 0.027$, $p = .0004$. Some significant effects and trends also emerged with respect to the smile initiator's mood: Increased mutual-smile hazard predicted significantly decreased negative mood, $B = -0.076$, Exp(B) = 0.927, $SE(B) = 0.038$, $p = .045$, and tended to increase positive mood, $B = 0.044$, Exp(B) = 1.045, $SE(B) = 0.025$, $p = .083$, although no significant effect emerged with respect to social bonding, $B = 0.022$, Exp(B) = 1.022, $SE(B) = 0.016$, $p = .180$.

Given that propensity to catch a smile appears to correspond to reward, sensitivity to alcohol's impact on smile infection might reinforce drinking and, thus, might be used to predict individual differences in typical drinking patterns. Consistent with this supposition, analyses revealed a significant interaction between alcohol condition and group-mates' typical drinking patterns, $B = 0.091$, Exp(B) = 1.096, $SE(B) = 0.033$, $p = .006$. Among groups who consumed alcohol, a smile was significantly more likely to be "caught" if the smile initiator's group-mates were heavier versus lighter drinkers. More specific,

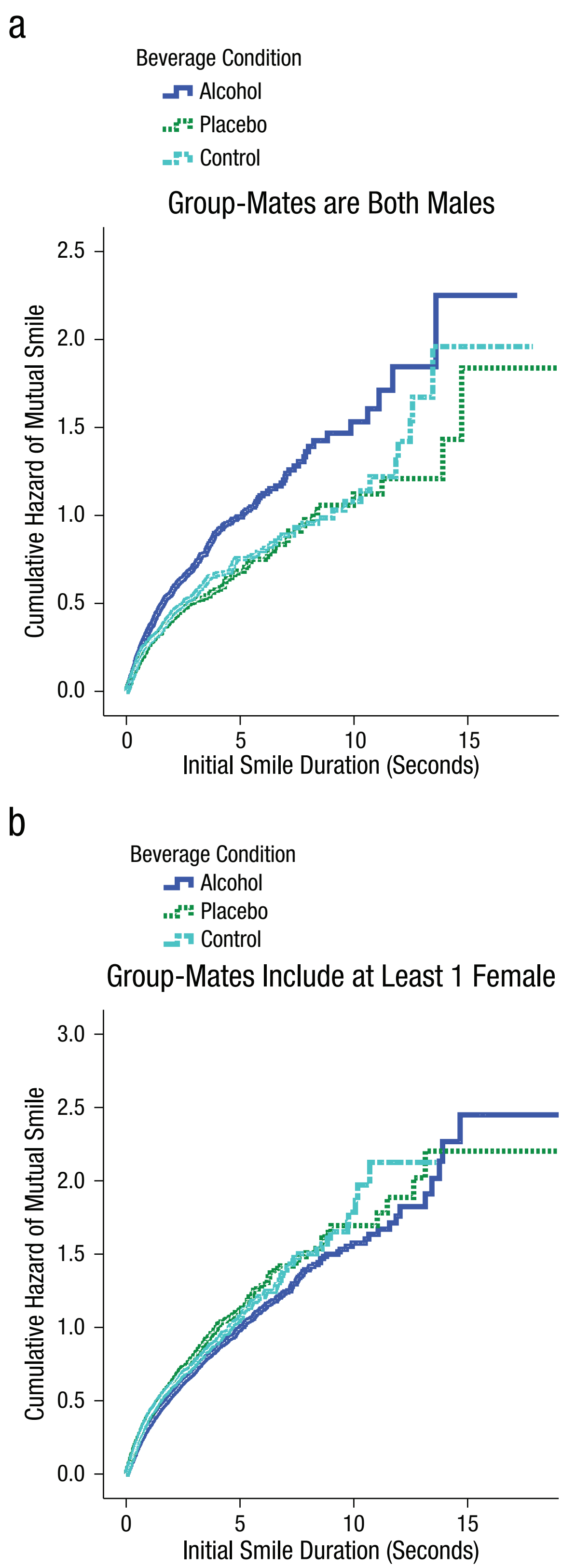

Fig. 2. Results: cumulative hazard of a smile developing into a mutual smile as a function of beverage condition and gender of the smile initiator's group-mates.

within the alcohol condition, there was a significant positive association between mutual-smile hazard and group-mates' typical drinking quantity, B = 0.055, Exp(B) = 1.056, SE(B) = 0.026, p = .037, such that a 5.6% increase in hazard of mutual smile corresponded to an increase of 1 standard drink per typical drinking occasion. In contrast, drinking patterns did not significantly predict mutual-smile hazard in the placebo and control conditions. The smile initiators' typical drinking patterns did not significantly predict hazard of mutual smile in any of the beverage conditions (p = 72). The effect of group-mates' typical drinking patterns was most pronounced in models that examined drinking quantity (average drinks per occasion; results reported earlier), whereas the effect of drink frequency alone did not reach significance (p = .69). Of note, models that examined total alcohol consumed (quantity × frequency) did reveal a significant Alcohol Condition × Group-Mates' Drinking Pattern interaction, B = 0.017, Exp(B) = 1.017, SE(B) = 0.007, p = .016. Although gender was a powerful predictor of drinking quantity among participants in our study, t = 9.500, p < .0001, with men consuming significantly more alcohol per drinking occasion than did women, the effect of typical drinking patterns emerged as significant even in models that controlled for all moderated and unmoderated effects of gender. Interestingly, associations of smile hazard with group-mates' drinking patterns appeared to be specific to the infection model (when one group member is already smiling) and did not emerge as significant within the noninfection framework discussed earlier (p = .98). Thus, results suggested that the infectiousness of smiles in a group drinking setting could have specific and clinically meaningful implications for social reward and alcohol-related reinforcement.

What about non-Duchenne smiles?

To test whether effects investigated here were specific to "emotion"-related expressions—whether effects could truly be called emotional contagion—we examined whether significant findings reported earlier would generalize to models focused on non-Duchenne smiles. Results suggested that catching a non-Duchenne smile was not associated with self-reported reward (ps > .28) and did not interact with alcohol condition to predict typical drinking patterns (p = .19). Furthermore, unlike Duchenne smiles, gender effects did not vary significantly by alcohol condition in models of non-Duchenne smiling infection (p = .11).

Discussion

For years, the proposition that alcohol consumption differentially affects emotion for men and women has been debated. A typical conclusion is that gender ought to influence the effects of alcohol, but the experimental findings are stubbornly complex if not downright inconsistent (Sher, 1987; Sutker, Allain, Brantley, & Randall, 1982). We have argued here that a vigorous investigation of the moderating impact of gender on the alcohol-emotion relation requires consideration of social context. Although at first glance this position seems to be fairly straightforward, in fact, it is at odds with the majority of experimental alcohol research.

Indeed, emotions and motivations associated with social drinking are not widely believed to carry serious implications for the etiology of alcohol-use disorder. Unlike individuals who consume alcohol while alone, those who drink to intoxication in a social setting do so with the implied social sanction and, perhaps, facilitation of those individuals in their proximal environment. Thus, although the affective experience of solitary drinkers is presumed to be truly "intrinsic" and "fundamental," we assume that the emotional and motivational forces that drive alcohol consumption in a social setting are "watered down" and "secondary" in comparison. Research practices are consistent with such assumptions: Researchers seldom incorporate social-drinking paradigms into alcohol-administration studies, and drinking in social settings has rarely been subject to serious scientific scrutiny. These assumptions and practices not only overlook the fact that regardless of an individual's problem-drinking status, the majority of drinking occurs in social settings but also disregard research that has suggested that social motives are among the most fundamental that humans possess. Indeed, our own experience dictates that emotions that manifest during social interactions can be overwhelming. The reward we experience when we share a genuine smile of enjoyment with another individual certainly can represent a powerful motivational force. It is in this context that the present study, which integrates research and methods across several domains of psychology, should be considered.

Using dynamic measures of affective experience and a multilevel statistical approach, we examined the impact of alcohol consumption and group gender composition on the spreading of smiles within groups. Specifically, we tested the effect of alcohol and group gender on the probability that an initial smile would develop into a mutual smile. Our initial event-level set of analyses focused on the likelihood that an initial smile, irrespective of its duration, would develop into a mutual smile. This analysis represents the dominant statistical approach to the examination of social interaction (Bakeman & Gottman, 1997). Results indicated that groups that consumed alcohol were more likely to reciprocate a smile than were groups that consumed nonalcoholic beverages. That is, alcohol increased the probability that an initial smile would develop into a mutual smile. Furthermore, this effect of alcohol appeared to be more pronounced for men than for women.

By themselves, these initial analyses leave unresolved critical questions regarding the nature of this interaction between gender and alcohol. Indeed, had we stopped at this stage in our analysis, we might have mistakenly assumed that alcohol consumption enhanced social responsiveness and emotional contagion, with alcohol qualitatively altering the infectiousness of initial smiles. Alternatively, a mutual smile may occur because the initial smile lingers in an unreciprocated state for a long enough time that eventually another group member responds. The increased likelihood of a mutual smile would not be due to any fundamental change in the inherent infectiousness of the initial smile. The event-level analysis cannot disentangle these conceptually distinct possibilities.

Survival analysis allows for a complex consideration of not only event sequence but also event duration. When we applied survival analysis to our data, we found that the main effect of alcohol on increasing mutual smiling was fully accounted for by increases in initial-smile duration. These results suggest that alcohol's global tendencies to increase mutual smiling in social settings may not result from increases in emotional contagion or social responsiveness but, instead, may stem from individual-level effects on something akin to "social bravery" (Fairbairn & Sayette, in press; Fairbairn, Sayette, Levine, Cohn, & Creswell, 2013). Alcohol appears to increase individuals' willingness to allow their "true smiles" to linger longer in a social setting and, as a result, increases the likelihood that they will ultimately meet with a responding smile.

When we considered the impact of gender, our survival analyses indicated that men derive more reward from alcohol than do women and that this reward manifested as a specifically social, catching process. Among men, alcohol-related increases in mutual smiling are not entirely accounted for by increases in the duration of the initial smile. Alcohol increased smiling infectiousness selectively among all-male groups but not among groups that contained females. Sober all-male groups displayed lower rates of smile contagiousness than did groups containing females, and alcohol consumption eliminated this male-group deficit in smiling infection. Further analyses revealed that this significant group-level interaction was not driven by the gender of the smile initiator but was instead driven by the gender of the smile initiator's groupmates—the gender of those who might be infected by a smile. Thus, results suggest that alcohol selectively enhanced the probability that a man will catch a smile in a social-drinking context.

In addition, we used survival analysis to examine whether effects of predictors on the probability of mutual smiling varied across the duration of the initial smile. We found that sober male deficits in hazard to mutual smiling did not arise instantaneously but, instead, became more pronounced as initial-smile duration progressed. Prior research has shown that men and women do not differ in levels of emotional mimicry when viewing pictures of emotional faces at subliminal exposure times; rather, gender differences emerge selectively at superliminal levels of exposure (Sonnby-Borgstrom et al., 2008). Consequently, when considered in light of prior research, our results suggest a role for more deliberative processes in gender differences in emotional mimicry. Consistent with research that has documented alcohol's tendency to reduce controlled inhibition, results of this study hint that alcohol may reduce gender differences in emotional contagion by disrupting nonautomatic processes that otherwise would constrain mimicry among sober men.

Finally, survival analyses revealed links between smile infectiousness and indexes of reward and alcohol-related reinforcement. Increased probability of catching a smile was associated with enhanced reported mood and perceived social outcomes. Furthermore, selectively in the alcohol condition, individuals who were more likely to be infected by a smile were more likely to report being heavier drinkers outside the laboratory. The relationship between drinking pattern and smile infection was independent of gender and, when considered together with self-reported reward findings, suggests that smile infection could represent an important indicator of alcohol-related reinforcement and a mechanism supporting drinking

Limitations of this study should be noted. First, we employed a single moderate dose of alcohol and tested the responses of individuals while on the ascending limb of the BAC curve. Future studies should test the generalizability of these results to higher and lower doses of alcohol and to individuals whose BACs are descending. Second, the current research focused on emotional contagion by using a measure of positive emotion (the smile) and a nonthreatening social-interaction paradigm. Further research might explore alcohol's impact on the contagion of negative emotion during threatening or stressful social interaction. Third, we examined alcohol's impact on smiling only in a social setting and not among participants consuming alcohol while alone. Although previous research does not support the notion that alcohol increases smiling duration among participants drinking in isolation (Ruch, 1994; Sayette et al., 2001), we are nonetheless unable to definitively claim that effects observed in this study are uniquely social phenomena or, for example, that alcohol's effects on increasing smile duration represent a manifestation of social bravery. Furthermore, we examined effects of alcohol among groups of individuals who were not previously acquainted; future research should focus on the generalizability of these findings to groups at all stages of social integration (Fairbairn & Sayette, in press). Fourth, we identified only one potential source of alcohol-related reinforcement. We do not claim that smile infectiousness is the only or even the most important manifestation of the reward that might be derived from drinking alcohol. Other factors—for example, the duration of the mutual smile—may also support alcohol-related reward and reinforcement value. Finally, the present paradigm mirrors common real-world situations in which all members of a social group consume alcohol together. Future research would be indicated to extend these findings by varying beverage condition within groups.

In summary, in the present study, we integrated theory and methods from diverse fields to examine the impact of alcohol on social experience. Results provide evidence that suggests that the social rewards associated with alcohol consumption are especially pronounced for male drinkers. Findings indicate a novel yet fundamental source of reward for male social drinkers and provide new directions for research that explores the role of social factors in the etiology of alcohol-use disorder.

Author Contributions

C. E. Fairbairn developed the study concept. M. A. Sayette developed the study design and participated in data collection. C. E. Fairbairn analyzed and interpreted the data under the supervision of A. Frigessi and O. O. Aalen. C. E. Fairbairn drafted the manuscript, and M. A. Sayette critically revised the manuscript. All authors approved the final version of the manuscript for submission.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Notes

1. "Emotional contagion" and "emotional mimicry" are closely related phenomena (Chartrand & Lakin, 2013); the latter is considered the primary mechanism through which the former takes place (Hatfield et al., 1995). Both terms are used in this article.
2. The full four-cell balanced placebo design has fallen out of favor in recent years, given that participants provided with false information that they are not receiving alcohol are generally not deceived (Martin & Sayette, 1993; Testa et al., 2006). As a consequence, we employed a three-cell design examining alcohol, placebo, and control conditions.

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