# The Effect of Alcohol on Emotional Inertia: A Test of Alcohol Myopia

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**In Press:** ***Journal of Abnormal Psychology***

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Abstract

Alcohol Myopia (AM) has emerged as one of the most widely-researched theories of alcohol's effects on emotional experience. Given this theory's popularity it is notable that a central tenet of AM has not been tested—namely, that alcohol creates a myopic focus on the present moment, limiting the extent to which the present is permeated by emotions derived from prior experience. We aimed to test the impact of alcohol on moment-to-moment fluctuations in affect, applying advances in emotion assessment and statistical analysis to test this aspect of AM without drawing the attention of participants to their own emotional experiences. We measured emotional fluctuations using autocorrelation, a statistic borrowed from time-series analysis measuring the correlation between successive observations in time. High emotion autocorrelation is termed "emotional inertia" and linked to negative mood outcomes. Seven-hundred-twenty social drinkers consumed alcohol, placebo, or control beverages in groups of three over a 36-min group formation task. We indexed affect using the Duchenne smile, recorded continuously during the interaction (34.9 million video frames) according to Paul Ekman's *Facial Action Coding System*. Autocorrelation of Duchenne smiling emerged as the most consistent predictor of self-reported mood and social bonding when compared with Duchenne smiling mean, standard deviation, and linear trend. Alcohol reduced affective autocorrelation, and autocorrelation mediated the link between alcohol and self-reported mood and social outcomes. Findings suggest that alcohol enhances our ability to freely enjoy the present moment untethered by past experience and highlight the importance of emotion dynamics in research examining affective correlates of psychopathology.

*Keywords*: alcohol, alcohol myopia, emotion dynamics, emotional inertia, social interaction

> It is the present—the conversations, the salient events and thoughts—that reigns over awareness. The sipping continues, as if to further intensify the present, to further draw out its distinction from the rest of experience, to leave the rest behind. Like being on a raft that has shoved off from the bank, there is a lifting feeling of having broken away. (Steele & Josephs, 1988)

Understanding why people drink and why they grow to depend on alcohol has been a longstanding research priority (e.g., Conger, 1956). In order to understand alcohol's reinforcing properties, researchers have focused on alcohol's impact on emotions (Lang, Patrick, & Stritzke, 1999). Over the past quarter century this work has evolved to incorporate a variety of cognitive constructs to explain the link between alcohol consumption and emotional experience (cf. Hull, 1987; Sayette, 1993). Arguably the most prominent of these modern approaches is Alcohol Myopia (AM) theory (Steele & Josephs, 1990). This theory emphasizes immediate subjective experience in explaining alcohol's "prized and dangerous" effects. Steele and colleagues propose that alcohol's impact on emotional experience is mediated by its tendency to limit attention to immediate aspects of existence. AM suggests that alcohol constrains our ability to connect immediate experience with prior experience, limiting the extent to which the present is permeated by emotions derived from pre-existing thoughts and ideas.

Alcohol myopia theory has inspired a considerable body of research (e.g., Curtin, Patrick, Lang, Cacioppo, & Birbaumer, 2001; Fleming et al., 2013; Giancola, Josephs, Parrott, & Duke, 2010; MacDonald, Fong, Zanna, & Martineau, 2000; Monahan & Lannutti, 2000; Sevincer, Oettingen, & Lerner, 2012). Compelling tests of AM have proceeded on the micro-level, tracking response times in milliseconds to demonstrate that alcohol's stress-relieving properties are linked to reduced attentional resources (Josephs & Steele, 1990). Nonetheless, considering the popularity of AM, it is striking that a fundamental element of the model has rarely been empirically scrutinized (see Fleming et al., 2013). Steele and Josephs (1990) assert that alcohol acts to draw out the immediate aspects of existence and distinguish the present moment from the past. They also acknowledge, however, that while they have tried to experimentally rule out alternative explanations, they have never tested whether alcohol does in fact distinguish present momentary affective experience from the past— never examined whether the present moment has indeed "broken away." While subsequent research has used EEG measures and attentional tasks to firmly establish a broad role for cognitive deficits in mediating alcohol's positive effects on mood (e.g., Curtin et al., 2001; Sher, Bartholow, Peuser, Erickson, & Wood, 2007), this work does not examine the assumption of AM that alcohol-related cognitive disruptions manifest in temporal discontinuity of affective experience. The present study employed a social interaction paradigm and applied advances in emotion assessment and quantitative methods in order to test a proposition of AM theory that alcohol increases temporal discontinuity of affective experience, allowing the present to break free of the past. We further tested whether increased temporal discontinuity caused by alcohol was associated with positive mood[1] outcome.

***Autocorrelation and Emotion Dynamics***

A direct examination of the predictions of AM requires advanced over time analysis, and statistical methods in psychology have not always kept pace with theory. Researchers have recently adopted the index of autocorrelation, a measure of temporal dependency[2] borrowed

[1] For the purposes of the current research, the term "affect" is used to refer to an immediate emotional state reflecting an individual's appraisal of an internal or external stimulus on a moment-to-moment basis, whereas "mood" is used to refer to a more pervasive and long-lasting emotional state (Batson, Shaw, & Oleson, 1992).
[2] Temporal dependency is a statistical term that refers to the relationship between different time points within the same series. In the present study, temporal dependency is operationalized as autocorrelation and can be conceptualized as the inverse of "temporal discontinuity" referred to above.

from time series analysis, to examine the relationship between past and present affective experience (Jahng, Wood, & Trull, 2008). First order autocorrelation measures the correlation between an individual's emotion at the present moment with his/her emotion during the preceding time interval (Gottman, 1981).

Importantly, autocorrelation indexes temporal fluctuations without reference to the source (i.e., internally or externally-generated) of these fluctuations. AM recognizes that alcohol can help focus attention on immediate internal experiences as well as external cues. Recent research has linked alcohol to increased creativity (Jarosz, Colflesh, & Wiley, 2012), and mind-wandering research confirms that alcohol consumption enhances distraction generated *internally* by thoughts and feelings (Sayette, Reichle, & Schooler, 2009). Emotional states can be altered by internally-generated experiences (Ochsner, Bunge, Gross, & Gabrieli, 2002), and distracting thoughts arising spontaneously in the minds of individuals consuming alcohol may sometimes divert them from their worries. Despite a potentially important role for internally-driven distractions in mediating alcohol's stress relieving properties, prior tests of AM have concentrated exclusively on alcohol's effects on responding to external cues (Fleming et al., 2013; Josephs & Steele, 1990). Autocorrelation provides a general measure of affective stability or "distractibility" regardless of whether the distractors are internally or externally generated, and is therefore ideally suited to capture affective shifts within the context of AM.

Autocorrelation is distinct from more commonly used indexes of change over time such as standard deviation and trends. Linear and quadratic trends delineate a pattern of means rather than a relationship between points of observation and are therefore not ideal when testing theory pertaining to fluctuations over time. Standard deviations assess the average distance of each observation from the mean without accounting for the order of observations. Very high and very low affective states observed in close temporal proximity would therefore have the same impact on standard deviation as these same two disparate observations separated by a large amount of time. While measures of variance such as standard deviation are thought to index overall emotional extremity, temporal dependency indexed using autocorrelation has been connected to emotional responsiveness or, conversely, resistance to change (Kuppens et al., 2012; Kuppens, Allen, & Sheeber, 2010). Thus, providing an index of the relationship between past and present affective experience that is sensitive to the order of observation and robust to individual differences in overall level of emotional extremity, autocorrelation provides an index of emotional responsiveness that is well-suited for a test of AM.

### ***Alcohol Myopia Manipulation and Measurement***

A key prediction of AM is that concurrent distraction is necessary for moderate alcohol consumption to provide emotion-enhancing effects. Steele and colleagues suggest that alcohol's myopic impact on attention allows us to become fully engrossed in an ongoing distraction—to lose awareness of underlying anxieties as we let go and become absorbed in the "flow." Nonetheless, tests of AM employ measures and manipulations that seem to rudely interrupt the very state of blissful distraction they seek to study, driving emotional experience into awareness and perhaps biasing the direction of thoughts towards stressful stimuli.

Cognitive researchers have identified two distinct states of awareness: *experiential consciousness* and *meta-consciousness* (Schooler, 2002). Experiential consciousness focuses on the contents of one's experience and involves information that one does not access until prompted. Meta-consciousness involves explicit awareness of the contents of consciousness and is information that becomes accessible with prompting (Smallwood & Schooler, 2006). Elements of experimental method, including measures and manipulations, can serve as "probes" that draw an individual from a state of experiential consciousness into the state of meta-awareness (Sayette et al., 2009; Schooler & Schreiber, 2004). In other words, these probes would necessarily induce an underlying negative emotional state to become immediately salient if a stressor looms.

In our test of AM, we aimed to unobtrusively follow participants as they became engrossed in an ongoing activity—tracking the ebb and flow of affective experience without using measures and manipulations that might interrupt or jolt emotion into meta-awareness. We used a group formation paradigm, selected as an emotion induction procedure that more closely resembles naturalistic drinking settings. Most alcohol consumption occurs in social settings (Cahalan, Cisin, & Crossley, 1969; Demers et al., 2002; Single & Wortley, 1993), and social mood-enhancement is among the most highly endorsed reasons for drinking (Cooper, Russell, Skinner, & Windle, 1992). Further, social settings are associated with a variety of emotional experiences that are particularly relevant for tests of AM theory (Josephs & Steele, 1990)—social interactions involving strangers not only elicit anxiety but also can serve as a source of positive emotions and distraction (Leary & Kowalski, 1995).

In addition to seeking a *manipulation* that would minimize attention to affective state, we furthermore sought a *measure* of affect that would allow us to unobtrusively but reliably track momentary fluctuations in affect. Self-report measures serve as probes, drawing the attention of participants to their affective states. If self-report measures are administered simultaneously with a stress/distraction manipulation, as in many tests of AM, these measures should undermine the ability of pleasant distraction to alleviate stress (see Sayette, 1993). In contrast to self-report, certain behavior-expressive measures can monitor experiential affect unobtrusively.

Advances in systems of behavioral measurement enable precise capture of streams of ongoing behavior (Bakeman, 1999). We used the *Facial Action Coding System* (FACS) (Ekman, Friesen, & Hager, 2002) to index ongoing behavioral affective display. FACS is the most comprehensive system available for coding visible facial expression. 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 et al., 2006). Unlike other types of smiles such as "social" smiles, Duchenne smiles have been associated with "felt" rather than simply "displayed" emotion (Ekman & Rosenberg, 1997). Duchenne smiling has been linked to positive affect while no-smiling in many social contexts is associated with negative affect (Lee, Jee, Park, Kim, & An, 2007). Facial behavior of participants was monitored continuously through the use of inconspicuous video cameras.

While a self-report questionnaire can disrupt experiential processing in the moment, it is ideally suited to capture reflective judgment of mood after an experimental manipulation of affective state and attentional focus is complete (Schooler & Mauss, 2010). Thus, in the present study we did not rely on self-reported measures to capture affective fluctuations during our study task, but rather administered questionnaires after the task was complete, thereby measuring meta-conscious mood without intruding on affective flow during the manipulation itself.

***The Current Study***

Using a continuous measure of affect together with concepts from time series analysis, we aimed to test how alcohol impacts moment-to-moment fluctuations in emotional experience during an unstructured social interaction. We sought to capture this phenomenon through a rigorous micro-analysis of emotion elicited during a laboratory interaction, adopting a conservative 10-second window as the unit of analysis (Jaffe & Feldstein, 1970; Warner, Waggener, & Kronauer, 1983; Warner, 1979). Participants in the current study drank alcohol, placebo, or control beverages as they interacted in groups of three. Initial findings from this dataset (Sayette, Creswell, Dimoff, Fairbairn, Cohn, Heckman, et al., 2012) focused on behaviors averaged across all time points during a protracted interaction without accounting for change over time and tested no mechanism through which alcohol might have induced positive emotional outcomes. The large sample of social drinkers, micro-analysis of affective display, and robust effects of alcohol observed in this dataset provide an optimal platform to examine how temporal fluctuations might explain alcohol's rewarding properties. In the present study, we used novel hierarchical modeling procedures (Kashy, Donnellan, Burt, & McGue, 2008; Olsen & Kenny, 2006) that incorporate comprehensive controls for between-subject covariance parameters, thus accounting for the complex interdependence in behavioral display observed in naturalistic small group settings.

Consistent with AM, we predicted that participants consuming alcohol while interacting with a group of strangers would exhibit less temporal dependency in subjective experience, exhibiting lower autocorrelations than those consuming no alcohol. Further, we predicted that lower autocorrelation in Duchenne smiling would mediate the positive effect of alcohol on self-reported mood and bonding.

# Method

## *Participants*

As detailed elsewhere (Sayette, Creswell, et al., 2012), healthy male and female social drinkers aged 21-28 were recruited via ads in local newspapers. Those who successfully completed an initial phone screening were invited to the Alcohol and Smoking Research Laboratory for a screening session. Following informed consent, exclusion criteria were assessed. Exclusion criteria included: medical conditions that contraindicated alcohol consumption, past alcohol abuse or dependence, as indexed by DSM-IV, pregnancy in females, not being within 15% of ideal weight for height, and being uncomfortable with study drinking requirements. Participants had to report they could comfortably drink at least 3 drinks in 30-min. Eligible participants (n= 720) were invited to participate in the experiment (83% European-American, 11% African-American, 1% Hispanic, 2.5% Asian, and 2.5% other). Half the participants were male and half female. Participants reported drinking 2-3 times/week and consuming 4.29 (*SD*= 1.89) drinks/occasion.

***Procedure***

Participants who answered advertisements were informed that the purpose of the study was to measure alcohol's impact on cognitive performance. Participants were randomly assigned to groups of three. Twenty groups representing each gender composition (0 females and 3 males, 1 female and 2 males, 2 females and 1 male, 3 females and 0 males) were assigned to each beverage condition. All members of the same group were assigned to the same beverage condition. Upon arriving in the lab, participants were casually and individually introduced to confirm that they were not previously acquainted (Kirchner, Sayette, Cohn, Moreland, & Levine, 2006). Participants then provided a breath sample to assess blood alcohol content (BAC) and completed a variety of self-report mood and personality assessments..

The three participants were then 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 (see below) 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 cranberry juice. 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. To adjust for gender effects, males in the alcohol condition were administered a .82g/kg dose of alcohol, while females were administered a .74g/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. Participants were instructed to drink their beverages evenly over the 12-min intervals and refrain from discussing how intoxicated they felt. Participants were otherwise not given instructions on whether to speak during the interaction period or what to talk about—participants were ostensibly seated in the same room to facilitate drink administration and communication with the experimenter.

Immediately following drinking, participants’ BACs were recorded, and they completed measures of mood and social bonding including an 8-item mood measure and Perceived Group Reinforcement Scale (see section on study measures). They then performed some additional cognitive tasks (Sayette, Dimoff, Levine, Moreland, & Votruba-Drzal, 2012). After BAC was again assessed, Placebo and control participants were debriefed, paid $50, and allowed to leave. Participants in the alcohol condition remained until their BACs dropped below .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 (e.g., Duchenne smiles) and speech 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 (1/30$^{th}$ of a second) of the interaction was manually evaluated by coders for the presence or absence of relevant facial AUs. 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. Coders were blind to experimental condition.

***Measures***

*Behavioral-Affective Display*: We indexed affect during the social interaction by measuring duration of "Duchenne" smiling (See Figure 1). Duchenne smiles include combined movement of the zygomaticus major (AU 12) and obicularis oculi muscles (AU 6) (Ambadar, Cohn, & Reed, 2009; Ekman et al., 1990). Reliability of facial coding, evaluated based on three minutes of video tape drawn from the beginning of the drink period, was assessed on a random subset of 72 participants. This sample included a total of over 500 Duchenne smiles, or at least one smile per participant evaluated. Coders showed excellent inter-rater agreement for Duchenne smiling ($\kappa$=.88).

*Baseline Self-Reported Mood*: The Positive and Negative Affect Schedule (PANAS) comprises two independent scales assessing current experiences of positive and negative mood. It consists of 10 items for positive and 10 for negative mood (Watson, Clark, & Tellegen, 1988).

*Post-Interaction Self-Reported Mood*: We assessed current positive and negative mood immediately after the interaction using an 8-item Mood Measure. We used a slightly different mood measure post-interaction compared with baseline to guard against anchoring effects and ensure that participants would modify their responses to reflect their current mood and not simply repeat their previous responses to the same questionnaire. The 8 item mood measure indexes four negative mood states (annoyed, sad, irritated, bored) and four positive mood states (cheerful, upbeat, happy, content) selected to represent all quadrants of the affective circumplex (Russell, 2003). Participants reported the extent to which they felt each of these 8 mood states on a 6 point likert scale from 0, “not at all,” to 5, “extremely.” Scores on the four positive items were averaged to create the positive mood subscale and scores on the four negative items created the negative subscale.

*Post-Interaction Self-Reported Social Bonding*: The PGRS included 12 Likert-type items, such as “I like this group” and “The members of this group are interested in what I have to say,” which were aggregated as a composite score ($\alpha$=.90). In the previous study, the PGRS correlated with non-verbal measures of social bonding (Kirchner et al., 2006).

### ***Data Analysis Plan***

The aims of data analysis were to: 1) Determine whether alcohol consumption decreases the temporal dependency of Duchenne smiling between successive time intervals (decreases autocorrelation); 2) Assess the validity of the autocorrelation construct by examining the extent to which autocorrelation predicts self-reported mood and social bonding measures; and 3) Determine whether decreases in autocorrelation partially explain alcohol’s positive influence on self-reported mood and social bonding.

There is no single, universally agreed-upon analytic procedure recommended for building many of the behavioral models detailed below (see Warner, 1998). As a conservative measure, we therefore tested the robustness of our findings in a variety of different models to ensure that significant effects reported here were not anomalies resulting from a unique set of model specifications. Results of alternative analyses are detailed in footnotes included throughout the results section.

Beverage Condition was initially represented as a complete orthogonal set of contrast codes, the first ("Alcohol") contrast comparing alcohol to both placebo and control conditions and the second ("Placebo vs. Control") contrast comparing placebo and control conditions (Cohen, Cohen, West, & Aiken, 2003). Theories informing our hypotheses deal with the pharmacological (i.e., ethanol consumed vs. no ethanol consumed) effects of alcohol (Steele & Josephs, 1990) and the parent study found no significant differences between placebo and control conditions in affective display (Sayette, Creswell, et al., 2012). After confirming that there was empirical justification for collapsing across placebo and control conditions in these analyses (significance of the Placebo vs. Control contrast) we represent alcohol condition as a single dummy code. All mood analyses control for positive and negative baseline mood.

*Data Processing*: Raw data files contained one point of observation for every frame of the social interaction period. Data were coded continuously throughout the 36 minute interaction with the exception of minutes 3-11 (only 29% of groups coded) and two additional minutes during which the experimenter entered the room to refill drinks, yielding a total of 34.9 million frames of behavioral data. Binary frame data were aggregated into ten second bins for analyses (Bakeman & Gottman, 1997), and aggregated data followed a Poisson distribution. Consistent with our prior research (Sayette, Creswell, et al., 2012) all alcohol analyses represent minutes 12-36 of the interaction—the period in which the effects of alcohol were hypothesized to be strongest. One participant was excluded from analysis for technical reasons.

*Aim 1 Alcohol and Autocorrelation:* To assess autocorrelation, an individual's Duchenne smiling duration at time *t-1* (referred to as the autoregressive coefficient) is entered as a predictor of that individual's Duchenne smiling at time *t.* Since autocorrelation can appear as a result of trends over time, models assessing autocorrelation controlled for linear and quadratic trends.

The examination of over-time processes among individuals clustered in dyads and small groups poses unique challenges. Traditional applications of hierarchical linear modeling (HLM) do not take account of the correlation of over-time components (e.g., autoregressive coefficients) among members of the same small group. Over-time processes observed among individuals clustered in dyads or small groups are most appropriately examined in models that account for not only within-subject slope and intercept variance and covariance, but also between-subject covariance of slopes, intercepts, and residual scores among members of the same group (Kashy et al., 2008; Olsen & Kenny, 2006). We expanded upon recommendations provided by Kashy, Donnellan, Burt, and McGue (2008) for over-time analysis of indistinguishable dyads so as to model the appropriate variance and covariance components observed in our groups of three. Finally, in order to control for the non-normal distribution of our outcome variable, we conducted hierarchical generalized linear modeling assuming a Poisson distribution and a log link function. All analyses controlled for overdispersion of residual scores.

*Aim 2 Autocorrelation and Self Report:* To accommodate the individual-level self-report outcome variable, average autocorrelation coefficients were estimated for each participant in our sample. These coefficients were then entered in a series of models considering other aggregate Duchenne smiling parameters (mean, standard deviation, and linear change over time) to predict three measures of self-reported mood and social bonding. We selected these three competing smiling indexes as measures that have been commonly employed as outcome variables in behavioral research (e.g., Kirchner et al., 2006; Smith et al., 1975) and/or measures that are related to and could be confounded with autocorrelation coefficients (Warner, 1998). First, we tested whether each aggregate parameter predicted positive mood, negative mood, and self-reported bonding when entered alone. Second, we tested models in which mean, standard deviation, and linear change were each entered together only with autocorrelation as predictors of self-reported mood and social bonding. Finally, we examined models in which all four aggregate smiling parameters were entered together. In all self-report analyses, HLM was used to account for the clustering of individuals within groups of three.

*Aim 3 Mediation of Alcohol's Subjective Effects*: In order to test whether autoregressive coefficients explain alcohol's effect on self-reported mood and social bonding, we tested whether an individual's average autocorrelation during the social interaction mediates alcohol's positive effect on subjective experience (Baron & Kenny, 1986). In all mediation analyses we used HLM to account for the clustering of individuals within groups (Krull & MacKinnon, 1999, 2001). We first confirmed that alcohol consumption had a significant positive influence on self-reported mood and social bonding (see also Sayette, Creswell, Dimoff, et al., 2012). Similar to procedures described above, we then estimated each individual's average autocorrelation during the social interaction, controlling for linear and quadratic trends. We tested whether a reduction in autocorrelation mediates alcohol's subjective effects by calculating the indirect effect (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002) and testing its significance using the Sobel standard error (MacKinnon, Warsi, & Dwyer, 1995; Preacher & Hayes, 2008).

## Results

### ***Beverage Manipulation Check***

BACs and measures of subjective intoxication appear in Table 1. Participants administered alcohol were on the ascending limb of the BAC curve with a BAC rising to about .06% immediately following the interaction period. All placebo and alcohol participants estimated that they had consumed at least 1 oz. of vodka. Consistent with our prior studies (e.g., Sayette et al., 2001), placebo participants reported experiencing some level of intoxication, more than control participants and less than alcohol participants.

***Baseline Individual Differences and Descriptive Statistics***

Age, marital status, income, smoking status, ethnicity, and positive and negative mood were equivalent across Beverage conditions, as were responses to questions about drinking history and current drinking patterns. Participants who received alcohol did not differ from no-alcohol participants on baseline self-report measures of positive, $B = .66$, $t = 1.18$, $p = .24$, or negative mood, $B = .04$, $t = .21$, $p = .83$. Descriptive statistics describing baseline and post-drink self-report ratings as well as the different aspects of smiling behavior across the three beverage conditions are presented in Table 2.

***Aim 1: Alcohol and Autocorrelation***

There was a significant main effect of the autoregressive coefficient after controlling for linear and quadratic time trends, $B = 1.70$, *EventRateRatio (ERR)* = 5.45, $t = 40.47$, $p < .0001$. A 1 unit increase in proportion of time spent Duchenne smiling during time interval *t*-1 was associated with a 5.45 fold increase in proportion of time spent Duchenne smiling at time *t*. As noted previously (Sayette, Creswell, et al., 2012), we also found a main effect of alcohol on Duchenne smiling—those assigned to the alcohol condition spent more time displaying positive affect than those assigned to receive no alcohol, $B = .18$, $ERR = 1.19$, $t = 4.62$, $p < .0001$.

Of particular interest to the present study, there was a significant interaction between the autoregressive coefficient and Alcohol condition, $B = -.37$, $ERR = 0.69$, $t = -4.43$, $p < .0001$ (Table 3).[3] While there existed a strong positive relationship between smiling at time *t-1* and

[3] In the model described above, only autoregressive coefficients were treated as random whereas linear and quadratic trends were treated as fixed. Due to the large number of random effects, the model failed to converge when more than one random slope was specified (see Kashy, Donnellan, Burt, & McGue, 2008 for a discussion of similar issues). However, the alcohol by autocorrelation interaction remained significant when the trends were

smiling at time *t* among all participants, the positive relationship was attenuated among participants consuming alcohol. Among sober participants, a one unit increase in proportion of time spent Duchenne smiling at time *t*-1 was associated with a 6.23 fold increase in Duchenne smiling at time *t*. In contrast among participants consuming alcohol, a one unit increase in proportion of time spent Duchenne smiling at time *t*-1 was associated with a 4.31 fold increase in Duchenne smiling at time *t*.

In order to further explore this alcohol by autocorrelation interaction and understand circumstances under which alcohol-related reward is maximized, we categorized observations according to whether there were high or low amounts of Duchenne smiles during the preceding time interval (*t-1*). The effect of alcohol on Duchenne smiling was over three times larger if an individual showed no smiling during the preceding time interval, $B = .51$, $ERR = 1.67$, $t = -4.43$, $p < .0001$, compared to if the individual smiled consistently throughout the preceding time interval, $B = .14$, $ERR = 1.15$, $t = 3.51$, $p = .0006$. The distinction between placebo and control conditions did not moderate autocorrelation, $B = .15$, $ERR = 1.16$, $t = 1.44$, $p = .15$.

In sum, results suggest that the temporal dependency of Duchenne smiling duration was lower among participants assigned to consume alcohol.[4]

***Autocorrelation and Subjective Effects***

As noted earlier, HLM was used to address the clustering of participants in groups of three. The correlations between the three post-interaction mood and social bonding variables were significant, though weak to moderate in magnitude: negative mood with social bonding, $\beta$ =

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treated as random and the autoregressive coefficient was fixed, $B = -.15$, $t = -4.40$, $p < .0001$, and when trends were first removed in a random-slope model, and then residuals were analyzed in a second model treating autoregressive coefficients as random, $B = -.0024$, $t = -3.63$, $p = .0004$.

[4] Although we selected a brief 10-second bin for our primary analyses, we do not believe that our findings are specific to that interval. For example, we reran the analyses doubling the interval to 20-sec. Results confirmed that alcohol attenuates the positive relationship between Duchenne smiling during successive twenty second bins, $B = -1.05$, $t = -5.73$, $p < 0.001$.

-0.36, $t = -10.18$, $p < 0.01$, social bonding and positive mood, $\beta = 0.38$, $t = 10.91$, $p < 0.01$, and negative mood with positive mood, $\beta = -0.34$, $t = -9.60$, $p < 0.01$. Given these moderate relations, each of these outcomes was examined in a separate model.

All four aggregate smiling parameters independently predicted self-reported mood and social bonding when entered in separate models. Standard deviation, mean, and linear trend in Duchenne smiling showed a positive correlation with self-reported positive mood and social bonding and a negative correlation with negative mood, and, consistent with predictions, autocorrelation showed the opposite pattern of findings, displaying a negative correlation with positive mood and social bonding and a positive correlation with negative mood (all *p*'s < .05).

When these parameters are examined in a single model the pattern of results alters and certain parameters appear to emerge as more powerful determinants of self-reported mood (Table 4). Importantly, we found a significant main effect of participants' average autocorrelation coefficient on self-reported positive mood, negative mood, and social bonding, even after taking into account variance attributable to the three other aggregate smiling parameters. Controlling for mean, standard deviation, and linear change over time in Duchenne smiling, we found that lower autoregressive coefficients were associated with more positive mood, $\beta = -0.73$, $t = -6.32$, $p < 0.0001$, less negative mood, $\beta = 0.46$, $t = 3.71$, $p < 0.0002$, and more perceived social bonding, $\beta = -0.28$, $t = -2.14$, $p = 0.03$.[5] An examination of standardized regression coefficients across all independent variables in the model suggests that autoregressive coefficients are the strongest predictor of two of the three self-report indexes. While the standard deviation index appears to be the strongest predictor of the Social Bonding measure, when results are considered together the standard deviation index produced mixed effects. Standard deviation shows a significant positive relationship with positive mood and social outcomes when examined alone

[5] Standardized regression coefficients are reported in this section to facilitate comparison across multiple IVs.

(see above) but a significant negative relationship with mood after controlling for other aggregate smiling parameters. Mean and linear change over time in Duchenne smiling show no consistent significant relationship with self-reported outcomes after controlling for the other aggregate smiling parameters. Finally, we examined these same effects in models in which mean, standard deviation, and linear change were each entered as predictors together with only autocorrelation. Results remain constant regardless of whether all parameters were entered into a single model (as reported above and in table 4), or each parameter was examined only with autocorrelation as predictors of self-reported mood and social bonding.

Entered as covariates, baseline negative mood, $\beta = 0.03$, $t = 8.88$, $p = <.0001$, and positive mood, $\beta = 0.06$, $t = 13.16$, $p = <.0001$, were significant predictors of post-interaction mood.

In sum, in assessing the validity of the autocorrelation construct, we found that autocorrelation emerged as the most consistent predictor of self-reported mood and social bonding when compared with more commonly used aggregate indexes of smiling mean and variability.[6]

### *Autocorrelation Mediating Alcohol's Subjective Effects*

We first confirmed that alcohol consumption significantly impacted scores on measures of self-reported mood. Alcohol was associated with significant increases in self-reported positive mood, $B = 0.23$, $t = 3.48$, $p = 0.0006$, decreases in negative mood, $B = -0.3106$, $t = -6.83$ $p < 0.0001$ and increases in social bonding, $B = 0.42$, $t = 2.63$, $p = 0.009$. With the exception of

[6] In the analyses reported above, means and standard deviations were estimated using traditional, ordinary least squares estimation. We also tested the relative strength of means and variances when these parameters were calculated in HGLM using empirical Bayes methods. Results were largely consistent with those reported above, with autocorrelation emerging as a significant predictor of both positive and negative mood, and a marginally significant predictor of self-reported social bonding (p=.051) after controlling for empirical Bayes parameters. The variance component estimated in HGLM was a less robust predictor of self-reported mood than the standard deviation estimated using OLS, showing no significant relationship with any measure of subjective experience after controlling for variance attributable to autocorrelation.

perceived social bonding, there were no significant differences between placebo and control groups in self-reported mood (see Sayette, Creswell, et al., 2012).

We next entered alcohol as a predictor of aggregate individual-level autocorrelation score, confirming that alcohol significantly decreases an individual's average autocorrelation in Duchenne smiling during the social interaction, $B = -0.002$, $t = -5.94$, $p < 0.0001$. We then entered both autocorrelation and alcohol in a single model predicting self-reported mood and social bonding. Controlling for alcohol consumption, we found that autocorrelation remained a significant predictor of self-reported positive mood, $B = -81.40$, $t = -6.78$ $p < 0.0001$, negative mood, $B = 30.27$, $t = 3.50$, $p = 0.0005$, and social bonding, $B = -64.96$, $t = -2.86$, $p = 0.004$. Alcohol remained a significant predictor of negative mood after controlling for autocorrelation, but no longer significantly predicted perceived social bonding, $B = 0.21$, $t = 1.72$, $p = 0.09$ or positive mood, $B = 0.09$, $t = 1.43$, $p = 0.16$. Finally, entered as covariates, baseline negative mood, $\beta = 0.07$, $t = 8.84$, $p = <.0001$, and positive mood, $\beta = 0.05$, $t = 13.32$, $p = <.0001$, remained significant predictors of post-interaction mood.

Based on coefficients derived from the analyses described above, we tested whether autocorrelation mediated the relationship between alcohol and positive subjective outcomes. We found that autocorrelation was a significant mediator of the relationship between alcohol and positive mood, $z = 4.46$, $p < 0.0001$, negative mood, $z = -3.01$, $p = 0.002$, and perceived social bonding, $z = 2.58$, $p = 0.009$. In other words, decreases in affective autocorrelation appear to partially explain alcohol's positive influence on mood and perceived social outcomes.[7]

[7] All analyses reported here control for trends in Duchenne smiling. When trends are not controlled all effects remain significant in the same direction and the level of significance is generally increased. Specifically, when only alcohol, lagged smiling, and their interaction are included in the model, there remains a significant interaction between alcohol and autocorrelation, B = -0.37, t = -4.44, p < .0001, and this lower autocorrelation mediates the relationship between alcohol consumption and increased positive mood, z = 4.21, p = .00002, decreased negative mood, z = -3.07, p = 0.002, and increased social bonding z = 2.75, p = 0.005.

## Discussion

This study examined whether alcohol influences the extent to which immediate experience is suffused by emotions derived from the past—a previously unexamined tenet of AM theory (Steele & Josephs, 1990). Using an unobtrusive observational measure and novel analytic procedures, we observed the impact of alcohol on moment-to-moment fluctuations in affective experience. Consistent with AM theory, we found that alcohol reduced the correlation between present and past affective display during an unstructured social interaction. First order autocorrelation was lower among participants consuming alcohol than among those consuming placebo and control beverages. Furthermore, we found evidence that autocorrelation mediates the impact of alcohol consumption on self-reported positive mood, negative mood, and self-reported social bonding. Our dynamic test of AM provides a crucial piece of missing evidence which—when taken together with findings from past studies establishing a role for attention in mediating alcohol's stress-relieving properties—suggest that alcohol may enhance mood by allowing individuals to freely enjoy the present and lose awareness of the past. Our findings further highlight the importance of considering dynamic affective fluctuations, captured here using the autocorrelation measure, when examining the experience of reward.

Affective shifts and changes are critical to many of the experiences we find most pleasurable. In film, the iconic "happy ending" is only enjoyable when the final blissful scenes are preceded by less cheerful passages. In music, the consonant chord that resolves a phrase is only pleasurable when proceeded by the dissonant dominant seventh chord or a brief foray into the relative minor key. Similarly, a novel written to comprise exclusively happy events would likely be considered insipid and abandoned by its disinterested reader. Artists and entertainers appear to implicitly understand what behavioral researchers have often ignored—reward may be best characterized as a dynamic progression of affective states that unfold over time.

While largely silent regarding the dynamic experience of reward, clinical psychologists have established firm links between high levels of emotional variability and psychological dysfunction. A broad range of negative psychological outcomes have been associated with high levels of emotional variability including depression, low self-esteem, borderline personality disorder, and bipolar disorder (e.g., Eid & Diener, 1999; Jahng et al., 2008). While at first glance these findings would seem incompatible with a dynamic conceptualization of reward, closer inspection suggests that variability associated with negative mood (often measured using indexes such as standard deviation) may not represent emotional responsiveness but rather overall range and extremity in affective experience (Larsen & Diener, 1987). The autocorrelation index used in this study provides a measure of moment-to-moment fluctuations in affective experience that is broadly independent of the range and extremity of emotions (Jahng et al., 2008). High emotional autocorrelation has been termed emotional inertia, and research has uncovered links between high emotional autocorrelations and negative psychological outcomes such as depression, low positive emotionality, and low self-esteem (Koval & Kuppens, 2011; Kuppens et al., 2012, 2010; Suls, Green, & Hillis, 1998). To our knowledge, the current study is the first to compare affective autocorrelation to other more commonly used aggregate indices of affective state as a predictor of established self-report measures of mood and social bonding.

Findings of this study trouble traditional "static" conceptualizations of reward, with autocorrelation emerging as the most robust predictor of self-reported mood and social bonding when compared with more commonly used aggregate indexes of affective state. Lower temporal dependency was consistently associated with more positive mood and perceived social outcomes, and the autocorrelation index explained all the variance in mood attributable to the widely favored "mean." While standard deviation consistently emerged as a significant predictor of self-reported outcomes, the direction of this relationship reversed after accounting for autocorrelation, suggesting that emotional extremity—affective variation examined independently of temporal dependency—is likely associated with negative mood outcomes. Within the framework of a test of AM, our study further presents evidence that temporal dependency plays a central role in mediating reward associated with one of the most popularly used and widely abused drugs. In combination with prior research on autocorrelation (Koval & Kuppens, 2011; Kuppens et al., 2012, 2010; Suls et al., 1998) these findings suggest that affective fluctuations from one moment to the next—the "push and "pull" of emotional experience critical to so many of the experiences we find enjoyable—may be a defining element of subjective well-being. Moreover, given both cross-sectional and prospective studies linking high affective autocorrelation to depression (Kuppens et al., 2012, 2010), our finding that alcohol relieves "emotional inertia" presents an intriguing explanation for high rates of comorbidity between depression and alcohol dependence (Grant & Harford, 1995). The autocorrelation measure may present a valuable tool in future research exploring psychological precursors to alcohol dependence and, more broadly, the affective correlates of psychopathology.

This study furthermore offers methodological advances that may facilitate the study of affective processes within more naturalistic drinking settings. Researchers seeking to isolate mechanisms promoting drinking through experimental procedures have typically favored powerful targeted manipulations of emotion. While some studies have examined alcohol's effects in more naturalistic group drinking settings (e.g.,Fromme & Dunn, 1992; Sayette, Creswell, et al., 2012; Sher, 1985; Smith et al., 1975), few have studied the mechanisms through which alcohol generates positive feelings in these social environments. Unstructured interactions generate complex, interdependent sequences of cognitions and responses making them difficult to study (Bakeman & Gottman, 1997). Thus, investigation of underlying mechanisms has been largely absent from experimental research examining the effects of alcohol in social context. This is a concern, considering the prevalence of alcohol consumption in social settings, especially among the “social drinkers” typically recruited to participate in these studies. Using within-subject mediators and advanced over-time analyses that account for interdependence, this study offers new tools to researchers seeking to study the mechanisms that support alcohol-related reward in social environments.

Further scrutiny of results suggests that the decreased temporal dependency observed among participants consuming alcohol corresponds with a form of emotional resilience in social settings. The effect of alcohol on emotional display was twice as large if a participant had spent no time smiling during the previous time interval compared to if the participant had smiled continuously during the previous time interval. This finding suggests that alcohol enables participants to “bounce back” and experience positive emotion after periods of low pleasure, but has comparatively little effect when participants are already feeling good. These results are intriguing in light of recent research pointing to emotional resilience as an important correlate of social functioning and psychological well-being. For example, research has not identified individual difference criteria that moderate immediate negative response to social exclusion, but instead indicates that individuals differ substantially in how quickly they recover from this initial negative response. Specifically, individuals low in social anxiety and rejection sensitivity recover more quickly from negative social experiences (Ayduk, Gyurak, & Luerssen, 2008; Zadro, Boland, & Richardson, 2006). Thus, alcohol seems to artificially induce a form of social resilience that is typically observed only among high functioning individuals.

Limitations of this study should be noted. Our study employed a single moderate dose of alcohol and tested the responses of individuals while on the ascending limb of the BAC curve. The BAC's of participants in our study were likely to be relatively low, since we examined affective responding of participants soon after drinking began. However, as in most alcohol administration studies, our participants drank quite rapidly, and research suggests that, independent of absolute intoxication level, it is important to consider "rate of change" of intoxication when examining pharmacological effects of alcohol on subjective experience (Breslin, Mayward, & Baum, 1994; Martin & Earleywine, 1990). Future studies should test the generalizability of these results to higher and lower doses of alcohol and to individuals whose BACs are descending. Second, we chose a fine-grained 10- second interval to test autocorrelation and found this time frame to provide evidence supporting a key tenet of AM. We also replicated these results after doubling our time interval. Future studies are indicated to test the temporal generalizability of these results, testing whether drinkers are able to "leave behind" events in the more distant past using even longer time intervals across different paradigms.

Third, future research should examine alcohol's impact on autocorrelation in social interactions associated with negative emotions (e.g., interracial interactions) using alternative indices of affective state. Our Duchenne smiling has been primarily researched in relation to positive affective experience (Ekman et al., 1990) and may sometimes reflect social signaling as well as felt emotional experience (Soussignan & Schaal, 1996). We chose to focus on the Duchenne smile for several reasons including 1) Negative facial expressions were infrequent and brief among participants in our study and 2) Consistent with past research linking no-smiling to negative emotions in certain social contexts (Berenbaum & Oltmanns, 1992; Lee et al., 2007),we observed not only a positive correlation between Duchenne smiles and positive mood but also an inverse correlation between Duchenne smiles and negative mood, suggesting that Duchenne smiling may tap a range of affective experiences. Nonetheless, research targeting facial expressions with more specific links to negative emotion displays would be valuable.

Relatedly, our results were observed in a relatively informal and non-threatening interaction using a nonclinical sample, and highly stressful or conflictual situations might produce different findings. Consistent with research by Koval and Kuppens (2011) as well as the work of Steele and colleagues (Steele & Josephs, 1990), we agree that associations between mood and emotional inertia will likely vary as a function of the context. Indeed, consistent with both AM and emotional inertia theory, our data suggest that alcohol may increase sensitivity to the immediate environment (internal and external). Under different conditions than studied here (e.g., using depressed participants, administering high conflict challenges) alcohol's effects on emotional fluctuation may hinder self-regulation (Giancola et al., 2010).

Finally, in our mediation analyses we were unable to firmly establish temporal precedence in the relationship between our mediator and dependent variable. In other words, we were unable to conclusively determine that decreased autocorrelation caused improvements in mood or completely rule out the inverse causal pathway, and establishing the order of this relationship experimentally represents an important challenge for future research.

In sum, theory and research examining the impact of alcohol on emotion has advanced significantly in the past few decades. AM theory (Steele & Josephs, 1990) has offered a creative framework for understanding the effects of alcohol on social and emotional experiences. By capturing emotional experience without calling that experience into meta-consciousness and making it highly salient, this study provided supporting evidence crucial to AM theory, namely that alcohol increases temporal discontinuity of emotional experience. Indeed, as posited by the theory's progenitors, these data suggest that alcohol loosens the connection between past and immediate experience, and that this decreased temporal dependency can lead to an overall social enhancement. More broadly, the methods reported here hold promise for examining the flow of naturally occurring emotional experiences among individuals diagnosed with a range of psychopathologies.

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Author Notes

This research was supported by NIH Grant (R01 AA015773) to Michael Sayette and National Science Foundation Graduate Research Fellowship Grant (0753293-006) to Catharine Fairbairn. We thank John Dimoff, Michael Sayers, Bryan Heckman, Kasey Creswell, and the students and staff at the Alcohol and Smoking Research Laboratory for assistance collecting and coding data. We also thank Dr.'s Jeffrey Cohn, Thomas Kirchner, and John Levine for helpful comments regarding the group formation paradigm, Sarah Dermody for feedback regarding ideas in this draft, and Dr. David Kenny for assistance with data analysis.

Table 1. Beverage Manipulation Check

| | Alcohol | | Placebo | | Control | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | *F* |
| BAC after drinking | 0.055 [a] | 0.012 | 0.001 [b] | 0.001 | 0.001 [b] | 0.001 | 4825.72** |
| BAC 40-min after drinking† | 0.062 [a] | 0.011 | 0.001 [b] | 0.001 | — | — | 7116.15** |
| 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† | 35.12 [a] | 16.90 | 8.90 [b] | 10.80 | — | — | 410.12** |
| Highest Intox. | 43.53 [a] | 18.71 | 16.15 [b] | 11.11 | 0.61 [c] | 3.19 | 698.07** |
| Vodka Estimate | 7.11 [a] | 9.85 | 4.64 [b] | 5.44 | 0.05 [c] | 0.43 | 70.80** |

* p = < .05 ** p = < .001
† control participants not asked to provide these data
Notes. BAC = blood alcohol concentration. SIS = subjective intoxication scale. SIS and Highest Intox. were scored on scales ranging from 0 to 100. Groups with non-overlapping superscripts differed significantly (p < .05).

Table 2. Descriptive Statistics by Beverage Condition

| | Alcohol | | Placebo | | Control | |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| **Baseline Self-Report Measures** | | | | | | |
| Positive Mood | 26.0962[a] | 7.0844 | 25.7908[a] | 6.8757 | 25.0975[a] | 6.8680 |
| Negative Mood | 11.8109[a] | 2.5262 | 12.0125[a] | 2.5309 | 11.5232[a] | 2.3678 |
| **Post-Drink Self-Report Measures** | | | | | | |
| Positive Mood | 3.5302[a] | 0.8270 | 3.2156[b] | 0.8054 | 3.3141[b] | 0.8199 |
| Negative Mood | 0.3333[a] | 0.4227 | 0.6750[b] | 0.6205 | 0.6008[b] | 0.5934 |
| Social Bonding | 7.2185[a] | 1.2489 | 6.7364[b] | 1.5213 | 7.0660[a] | 1.3007 |
| **Duchenne Smiling During Drinking** | | | | | | |
| Mean (secs/10 sec interval) | 1.4790[a] | 0.8725 | 0.9366[b] | 0.7024 | 1.0197[b] | 0.7061 |
| SD (secs/10 sec interval) | 2.1458[a] | 0.7333 | 1.6155[b] | 0.7065 | 1.7067[b] | 0.6959 |
| Autocorrelation† | 1.6308[a] | 0.6401 | 2.1621[b] | 0.7829 | 2.0192[b] | 0.6771 |
| Linear Slope† (10 second intervals) | -0.0004[a] | 0.0023 | -0.0023[b] | 0.0018 | -0.0019[b] | 0.0018 |

† Represents unstandardized regression coefficient derived from HGLM model
Groups with non-overlapping superscripts differed significantly ($p < .05$).

Table 3. Hierarchical Generalized Linear Model Predicting Duchenne Smile Duration from Alcohol and Autocorrelation (Smiling During Previous Time Interval)

Fixed Effects

| | *B* | *ERR* | *t-ratio* | *p-value* |
|---|---|---|---|---|
| Intercept | -2.8447 | 0.0581 | -26.01 | <.0001 |
| Autocorrelation [1] | 1.8286 | 6.2252 | 35.92 | <.0001 |
| Alcohol | 0.5092 | 1.6640 | 6.11 | <.0001 |
| Alcohol*Autocorrelation | -0.3688 | 0.6916 | -4.43 | <.0001 |
| Linear Time | 0.001 | 1.0010 | 0.72 | 0.4703 |
| Quadratic Time | -.000005 | 0.999995 | -1.13 | 0.2581 |

Random Effects

| | *Estimate* | *Standard Error* |
|---|---|---|
| Intercept Variance | 0.5218 | 0.0392 |
| Between-Subject[2] Intercept Covar | 0.2625 | 0.0369 |
| Autocorrelation Variance | 0.4499 | 0.0492 |
| Between-Subject Autocorr Covar | 0.2026 | 0.0416 |
| Within-Subject Autocorr-Intercept Covar | -0.4613 | 0.0405 |
| Between-Subject Autocorr-Intercept Covar | -0.2246 | 0.0365 |
| Residual Variance | 0.1185 | 0.0015 |
| Between-Subject Residual Covar | 0.1716 | 0.0010 |

[1] Autoregressive coefficient at lag 1—subject's Duchenne smiling duration at time *t*-1 entered as a predictor of smiling at time *t*. [2] Between-subject covariance refers to the covariance in scores between the three members of the same group.

Table 4. Aggregate Indexes of Duchenne Smiling as Predictors of Self-Reported Mood and Social Bonding

Negative Mood

| | B | t ratio | df | p value |
|---|---|---|---|---|
| Mean | 0.01 | 0.09 | 470 | 0.9248 |
| Standard Deviation | 0.31 | 2.98 | 470 | 0.0030 |
| Autocorrelation | 0.46 | 3.71 | 470 | 0.0002 |
| Linear Growth | -0.05 | -1.19 | 470 | 0.2338 |
| Baseline Neg Mood | 0.12 | 8.88 | 470 | <.0001 |

Positive Mood

| | B | t ratio | df | p value |
|---|---|---|---|---|
| Mean | -0.29 | -2.64 | 469 | 0.0087 |
| Standard Deviation | -0.25 | -2.54 | 469 | 0.0115 |
| Autocorrelation | -0.73 | -6.32 | 469 | <.0001 |
| Linear Growth | 0.05 | 1.19 | 469 | 0.2335 |
| Baseline Pos Mood | 0.06 | 13.16 | 469 | <.0001 |

Social Bonding

| | B | t ratio | df | p value |
|---|---|---|---|---|
| Mean | 0.16 | 1.24 | 475 | 0.216 |
| Standard Deviation | -0.35 | -3.17 | 475 | 0.002 |
| Autocorrelation | -0.28 | -2.14 | 475 | 0.033 |
| Linear Growth | 0.07 | 1.39 | 475 | 0.165 |

Figure 1. Image of a Study Participant Displaying a Neutral Face (Left) and a Duchenne Smile (Right)