Pour Decisions: The Relationship Between Intoxication, Free-Pour Accuracy, and Subjective Impairment

by

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Abstract

Reducing risk associated with college student drinking is a major public health concern. The free-pour assessment has the potential to inform interventions aimed at reducing risks associated with college student drinking. Yet, few studies have assessed conditions that influence pouring abilities, and no identified studies have assessed pouring behavior under the influence of alcohol; further, no identified studies actual and perceived free-pouring behavior is subject to acute tolerance, which has been identified as an important factor in alcohol-related risk. It was hypothesized that ratings of subjective intoxication, free-pour accuracy, and ratings of free-pour accuracy would be subject to acute tolerance. Participants trained to pour a standard drink of beer received a dose of alcohol (n=7) or a placebo dose (n=6) and repeated free-pours and ratings of subjective impairment along the blood alcohol concentration (BAC) curve. Results suggested that participants were able to pour a standard drink of beer within the 10% training criterion range (12 oz) after a stimulus fading training procedure. Consistent with previous findings of acute tolerance, results supported the hypothesis that ratings of subjective intoxication were subject to acute tolerance. Inconsistent with hypotheses, free-poured ounces and subjective ratings of free-pour accuracy were not. These data suggest that free-pouring a standard drink of beer is a trainable skill that persists despite a moderate dose of alcohol. Future studies should examine if behavioral skills training of other protective skills in the context of elevated BAC reduces the risks associated with intoxication among college students.

Table of Contents

List of Tables

List of Figures

Pour Decisions: The Relationship Between Intoxication, Free-Pour Accuracy, and Subjective Impairment

College student alcohol use and the associated negative consequences are a major public health concern. Each year, alcohol use results in approximately 1,825 unintentional deaths, 599,000 unintentional injuries, and approximately 97,000 students are victims of alcohol-related sexual assault or date rape. Further, 25% of college students report academic problems (e.g., missing class, lower grades) resulting from alcohol use (National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2015). Nearly 60% of full-time students report to have consumed alcohol during the past month, with approximately 67% of those students reportedly engaging in binge drinking episodes (NIAAA, 2015). Binge drinking, defined by the NIAAA as consumption of alcohol that causes an individual's blood alcohol concentration (BAC) to meet or exceed 0.08 g/dl, typically occurs when males consume five or more drinks or females consume four or more drinks within a two-hour period. Elevated BACs resulting from binge drinking are associated with psychosocial consequences such as property damage, trouble with law enforcement, risky sexual behavior, and memory loss, among others (Turner, Bauerle, & Shu, 2004). As BAC continues to rise, there is increasing impairment and depression of the central nervous system, which can result in overdose and serious negative medical consequences such as vomiting, loss of consciousness, asphyxiation, seizures, coma, or death (NIAAA, 2015). Thus, evaluating drinking behaviors at elevated BACs is important for prevention and intervention efforts aimed at reducing risk associated with alcohol use.

Typically, data regarding college student alcohol consumption and associated negative consequences are collected via self-report measures, in which students report on their typical alcohol consumption, motives, decision making, or frequency of various positive and negative

consequences (Devos-Comby & Lange, 2008; Sobell & Sobell, 2004). Prevention strategies, such as social normative campaigns, utilize self-report data to reduce alcohol-related risk by correcting misperceptions regarding the quantity and frequency of alcohol use, as well as the type and frequency of alcohol related consequences (DeJong, 2002; Wechsler et al., 2003). Further, self-report data is used in brief interventions (e.g., Brief Alcohol Screening and Intervention of College Students) to provide personalized feedback to students in the form of average weekly or monthly alcohol consumption and BAC estimates, social normative information, and other personalized information aimed at reducing alcohol-related risk and the associated consequences (Baer, Kivlahan, & Marlatt, 1998).

The use of self-report data in interventions efforts is predicated on the notion that such data are sensitive enough to provide accurate and informative feedback. However, recent studies suggest that the reliability and validity of self-report data are limited in several ways. First, recent studies show that college students lack knowledge of standard drink size definitions (de Visser & Birch, 2012; Hasking, Shortell, & Machalek, 2005; Welsh et al., 2014; White et al., 2005; White, Kraus, McCracken, & Swartzwelder, 2003). If college students cannot accurately define standard drink sizes, they likely cannot accurately report how many standard drinks they have consumed during a drinking episode, especially if the drinks consumed were poured by themselves or by others (i.e., not from a can or bottle; Devos-Comby & Lange, 2008; Schultz, Kohn, Schmerbauch, & Correia, 2017). This has important implications for understanding the relationship between quantity and frequency of alcohol use and its correlates, including decision making, motives, and consequences. Second, self-report is sensitive to external variables, such that self-report can be differentially affected by how, when, where, and who collects the information (e.g., Bessa, Mitsuhiro, Chalem, Barros, Guinsburg, & Laranjeira, 2010; King, 1994;

Walker & Cosden, 2007). Third, self-reported data are provided retrospectively and based on "typical" patterns of consumption. While average alcohol consumption information can provide useful information for comparative feedback, using averaged data can mask important variability in alcohol use (Kohn, Schultz, Bettencourt, & Dunn-Carlton, 2017). Further, studies comparing actual to self-reported alcohol consumption show that individuals tend to underestimate the number of drinks consumed, with the discrepancy increasing as the total number of drinks consumed increases (Northcote & Livingston, 2011; Poikolainen, 1985). Fourth, some studies suggest that individuals vary their self-report across measures, suggesting poor reliability (Feunekes, van't Veer, van Staveren, & Kok, 1999; Heeb & Gmel, 2005; Hoeppner, Stout, Jackson, & Barnett, 2010). Lastly, self-report measures are typically validated against other forms of self-report such as collateral reports, diaries, interviews, and official records, which are subject to the limitations of self-report noted above (Midanik, 1988; Sobell & Sobell, 2004). Taken together, these findings suggest that self-reported alcohol consumption lacks reliability and validity, which has important implications for its use as a prevention and intervention approach.

Despite evidence suggesting that self-report may lack reliability and validity, it remains the primary method for establishing epidemiological data, which informs prevention and intervention strategies. However, recent research has focused on developing more objective measures for the quantification and prevention of risky alcohol use behavior (e.g., binge drinking). One approach, the free-pour assessment, has been used to measure standard drink knowledge and as an indicator of typical drink sizes (Schultz et al., 2017). Data from the free-pour assessment have the potential to improve our understanding of alcohol consumption and

related problems, inform prevention efforts, and provide more reliable and valid assessments and interventions (Devos-Comby & Lange, 2008).

Free-Pour Assessment

An alternative to self-report, the free-pour assessment is an objective measure for understanding alcohol consumption. According to a recent review, there are two general types of free-pour assessments (Schultz et al., 2017). The first measures individuals' typical pours in more naturalistic settings, such as in their home. The second assessment is typically conducted in laboratory settings and measures individuals' knowledge of standard drink sizes by measuring the deviation of their free-pour from standard drink size. While both provide important information in the context of drinking behavior, the standard drink knowledge free-pour assessment provides important information about an individual's ability to pour portion sizes consistent with portion sizes measured via self-report measures. If individuals are unable to identify or pour standard drink sizes, it is unlikely they can accurately report on the number of standard drinks they have consumed. Thus, the standard drink knowledge free-pour assessment has important implications for the validity of self-report, in addition to providing additional information regarding risk associated with various drinking levels. Particularly, standard drink knowledge free-pour studies indicate that students may be unintentionally under-reporting their consumption, and that self-report alone may not fully capture reliable and valid alcohol consumption data.

Standard drink free-pour assessments have been used as an alternative to self-report measures and can provide additional information about college students' alcohol knowledge and consumption patterns (White et al., 2005). The free-pour assessment has demonstrated that college students generally pour more than a single standard serving size of alcohol, particularly

wine and liquor, and pours increase with increased cup size (White et al. 2005; 2003; Zandy, Pang, Ho, & Matthews, 2013). However, several studies have also demonstrated that practice and training can improve free-pour accuracy (Wansink & van Ittersum, 2005, Metz, Kohn, Schultz, & Bettencourt, 2017), which may result in more accurate self-reports (White et al., 2005). Together, these studies suggest that individuals can be trained to pour accurate standard drink sizes, which in turn can be used to assess for conditions that affect free-pour accuracy.

To date, no identified studies have trained pouring behavior and assessed pouring accuracy while under the influence of alcohol. Thus, while it has been demonstrated that individuals can pour portion sizes consistent with standard drink sizes, it is currently unknown if this skill is maintained once alcohol has been consumed. However, an abundance of research has demonstrated the impairing effects of doses of alcohol on various motor abilities (Bernosky-Smith et al., 2011; Fogarty & Vogel-Sprott, 2002; Taylor et al., 2010). As free-pouring behavior requires motor skills similar to those assessed in previous studies, it is important to understand how intoxication impacts the ability to accurately pour a standard drink.

Impairment and Acute Tolerance

In addition to objective impairment associated with alcohol consumption, individuals also experience subjective impairment (e.g., reporting to feel drunk), which has been identified as an important factor in understanding alcohol-related risk (Brumback, Cao, & King, 2007; Morris, Amlung, Tsai, & McCarthy, 2015). Particularly, subjective impairment appears highly susceptible to acute tolerance (Holland & Ferner, 2017; Weafer & Fillmore, 2012), or "a decrease in a response to alcohol that occurs over time within a single exposure to this drug and that is independent of changes over time in BACs" (Martin & Moss, 1993, p. 1). Subjective impairment associated with acute tolerance is commonly measured using the Mellanby effect,

which compares impairment at the same BAC on both the ascending and descending limb. A recent systematic review of the Mellanby effect suggests that individuals tend to rate themselves as less intoxicated on the descending limb of the blood alcohol curve in comparison to the same BAC on the ascending limb of the blood alcohol curve. Acute tolerance to subjective impairment has been identified as an important factor in decision-making; particularly, individuals who rate themselves as less intoxicated on the descending limb are more likely to report willingness to drive (e.g., Amlung, Morris, & McCarthy, 2014; Holland & Ferner, 2017).

Although individual's perceptions of their level of intoxication appear to reliably demonstrate accurate tolerance, conclusions regarding acute tolerance of other behavioral indicators of alcohol-related risk are mixed (e.g., Cromer, Cromer, Maruff, & Snyder, 2010; Holland & Ferner, 2017; Weafer & Fillmore, 2012). For example, Cromer and colleagues (2010) demonstrated acute tolerance for simple visual motor responses, but executive functions failed to recover on the descending limb. Similarly, Weafer and Fillmore (2012) demonstrated acute tolerance for simple motor coordination, but driving performance did not recover. In their systematic review, Holland and Ferner (2017) note similar findings – improvements on the time to complete maze and pegboard tasks were observed, whereas inhibitory control and driving ability remained impaired. These findings are consistent with results from a review of acute tolerance of cognitive performance, which found that reaction times for cognitive tasks showed acute tolerance, whereas accuracy on the tasks did not (Schweizer & Vogel-Sprott, 2008). Together, these findings suggest that acute tolerance may differentially affect cognitive and behavioral skills (Moskowitz, Herbert, & Florentino, 2000). However, previous studies on behavioral indicators of acute tolerance have primarily focused on basic motor (e.g., reaction time) or cognitive (e.g., inhibitory) tasks that approximate distal alcohol-related behaviors, such

as decision-making or driving impairment. While failure to recover inhibitory control has been linked to abuse potential (e.g., binge drinking; Marczinski, Combs, & Fillmore, 2007; Weafer & Fillmore, 2008), no identified studies have measured the Mellanby effect on an objective behavior that has direct implications for drinking (e.g., free-pour task). Thus, the extent to which acute tolerance impacts actual and perceived free-pouring skills remains relatively unknown, as free-pouring is an integrative task that requires basic motor skills (e.g., turning the pitcher to pour beer), visuospatial skills (e.g., perception of volume), and cognitive skills (e.g., inhibition of over-pouring).

Conclusions regarding acute tolerance are further limited by failure to assess drinking history, particularly high-risk drinking behavior that may result in disordered alcohol use. Indeed, most studies exclude high-risk individuals and primarily assess behavioral impairment of light to moderate social drinkers (Holland & Ferner, 2017). Assessing acute tolerance among individuals with higher risk is particularly important to understanding the mechanisms and conditions in which acute tolerance is likely to occur. For example, Fillmore and Weafer (2012) demonstrated that recovery of motor skills was evident among at-risk binge drinkers, but not evident among non-risk drinkers. Assessing the facets of acute tolerance among high-risk drinkers is especially important given that individuals who engage in more frequent, heavy alcohol use consistent with binge drinking appear more likely to engage in risky decision-making (e.g., driving after drinking) despite impairment associated with intoxication (Bernosky-Smith et al., 2011; Marczinski, Harrison, & Fillmore, 2008; Marczinski & Fillmore, 2009).

In summary, assessing subjective impairment, or an individual's perception of their level of intoxication, has important implications for understanding alcohol-induced impairment as well as alcohol-related risk (e.g., decision making). Individuals who rate themselves as less impaired

or intoxicated while their BAC is falling are more likely to engage in high-risk behavior such as driving, despite evidence that motor abilities remain impaired (Amlung et al., 2014; Holland & Ferner, 2017; Weafer & Fillmore, 2012). However, no identified studies have examined the relationship between subjective impairment and an objective task that approximates drinking behavior among high-risk drinkers. Thus, research on the relationship between acute tolerance, subjective impairment and free-pour behavior would address a gap in the literature and has important implications for alcohol-related risk.

Purpose of study

Given the high prevalence of college student alcohol consumption and associated negative consequences, developing improved data collection methodologies that inform prevention and intervention techniques is warranted (Devos-Comby & Lange, 2008). The standard drink knowledge free-pour assessment is an objective measure of college student alcohol use behavior that has the potential not only to inform the accuracy of self-report, but inform interventions aimed at improving college students' alcohol-related knowledge (Schultz et al., 2017). However, few studies have assessed conditions that influence pouring abilities, and no identified studies have assessed the relationship between free-pouring behavior and subjective impairment under the influence of alcohol. The free-pour assessment provides a unique opportunity to assess behavior change resulting from intoxication, as previous research has demonstrated that pouring standard drink sizes is a trainable skill (Metz et al., 2017; Wansink & van Ittersum, 2005). Thus, the purpose of the current study is to assess the relationship between intoxication, ability to accurately free-pour a standard drink of beer, and subjective impairment. Specifically, this study examined differences in free-pouring behavior, subjective intoxication, and subjective accuracy at three time-points after receiving a dose or placebo dose of alcohol.

It was hypothesized that free-pour accuracy and subjective ratings of impairment would be subject to acute tolerance. Specifically, participants in the alcohol dose group would have larger free-pours and higher ratings of intoxication on the ascending (Time 2) and descending limb (Time 3) of the BAC curve compared to baseline (pre-dose; Time 1); free-pours and ratings of impairment were expected to be higher at time 2 pours than Time 3. In contrast, participants in the placebo dose group would have free-pours and ratings of intoxication that were consistent over time. Between groups, participants' free-pours and ratings of subjective intoxication would be similar at Time 1; Time 2 and Time 3 free-pours and ratings of intoxication would be higher for the dose group than for the placebo group. For subjective accuracy, an inverse relationship was expected. Specifically, it was hypothesized that participants in the alcohol dose group would have lower subjective ratings of accuracy on the ascending (Time 2) and descending limb (Time 3) of the BAC curve compared to baseline (pre-dose; Time 1); ratings of accuracy were expected to be lower at time 2 pours than Time 3. In contrast, participants in the placebo dose group would have ratings of accuracy that were consistent over time. Between groups, participants' ratings of subjective accuracy would be similar at Time 1; Time 2 and Time 3 ratings of accuracy would be lower for the dose group than for the placebo group.

Method

Participants

Figure 1 shows the flow of participants through the study. Undergraduate students from a large Southeastern university who were interested in the study and at least 21 years old first completed an online questionnaire via the SONA online data collection system to determine study eligibility. Participants that denied recent alcohol consumption consistent with an episode

of binge drinking in the past 28 days (i.e., 5 or more drinks for males, 4 or more drinks for females, within a 2 hr time-period), reported any physical or psychological conditions or prescription medications, or who indicated they would not like to be contacted about the laboratory portion of the study were excluded. The remaining participants were invited via e-mail within three weeks of submitting the screening questionnaire to participate in a laboratory session. Interested participants were directed to sign-up for a laboratory session using the SONA system.

From the invited participants, 14 students participated in the laboratory study. However, one participant's data were excluded due to a break in the double-blind. Specifically, the participant asked about leaving the study early after consuming the first drink. Due to concerns about whether or not the participant wanted to continue participating, the dosing RA spoke with participant to ensure the participant understood the parameters of continuing to participate. Further, after the first repeated measures (Time 2) but prior the final measures (Time 3), the participant asked if they were sober enough to leave, to which the non-dosing RA responded that they were not. Thus, any ratings of subjective impairment at Time 3 would not interpretable. Thus, the final sample consisted of 13 participants (30.8% Female, 69.2% Male) who were 21 years and older (M = 21.38, SD = 0.51). Overall, the sample was mostly Caucasian (61.5%), followed by African American (15.4%) and Asian (15.4%), and one participant identified as Native Hawaiian or Other (7.7%). Participants reported an average of 14.62 years (SD = 0.96) of school completed. The majority of participants (61.5%) denied being a member of a Sorority or Fraternity, and all 13 participants reported living in off-campus housing.

Online Survey Measures

Demographics and medical history. The first page of the screening questionnaire asked participants to answer basic demographic questions, including their age, gender, race, class standing, Greek status, and athletic status. The second page of the screening questionnaire asked participants to answer a series of yes/no questions regarding their medical history. Specifically, participants were asked to list any medical conditions and if they take prescription medications for those medical conditions. In addition, participants were asked to list any mental health diagnoses and if they take prescription medications for those medical conditions. Finally, female participants were asked to indicate if they are pregnant or planning on becoming pregnant.

Daily Drinking Questionnaire (DDQ). The DDQ is designed to assess daily alcohol consumption during a typical week during the past month (Collins, Parks, & Marlatt, 1985). Additionally, the DDQ assesses the number of standard drinks consumed during the heaviest drinking week in the past month, as well as the frequency of alcohol consumption and binge drinking episodes in the past 28 days. Consistent with NIAAA recommendations, binge drinking is defined as four or more drinks for females, or five or more drinks for males, within a single drinking episode. The DDQ is a psychometrically valid measure to assess alcohol use among college students (e.g., Baer et a., 1992; Witkiewitz et al., 2014). The DDQ was used to identify participants for the laboratory portion of the study.

Alcohol Use Disorder Identification Test (AUDIT). The AUDIT is an internally valid 10-item screening instrument designed to identify potentially problematic or harmful alcohol use over the past 6 months (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). Participants responded to alcohol use questions (e.g., “How often do you have a drinking containing alcohol?”, “How often during the past 6 months have you had a feeling of guilt or remorse after drinking?”) using a 5-point scale (0 = *never,* 4 = *Daily or almost daily*). Participants total

AUDIT scores were summed to create a single AUDIT risk score, with higher scores indicating higher risk for alcohol related problems. Internal consistency of the AUDIT in the current sample was good (Cronbach's alpha = 0.85); this is consistent with findings from previous studies using college student samples (Meneses-Gaya, Zuardi, Loureiro, & Crippa, 2009).

Rutgers Alcohol Problem Index (RAPI). The RAPI is an internally valid measure consisting of 23-items designed to assess problematic drinking in adolescents and young adults (White & Labouvie, 1989). Total scores are derived by summing responses to statements regarding problematic alcohol use (e.g., "kept drinking when you promised yourself not to") on a 4-point Likert scale (0 = *Never* to 4 = *More Than 10 Times*), with higher scores indicating more negative consequences of alcohol use (White, Labouvie, & Papadaratsakis, 2005). Internal consistency of the RAPI in the current sample was good (Cronbach's alpha = 0.87); this is consistent with findings from previous studies using college student samples (Buckner, Keough, & Schmidt, 2007; Stewart, Loughlin, & Rhyno, 2001).

Laboratory Measures

Breath Alcohol Concentration (BrAC). A handheld breathalyzer (Intoximeters Alco-Senso IV) was be used to collect baseline (i.e., pre-dosing) and post-dosing BrAC. Following dosing, BrAC was collected at 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, and 180 minutes after dosing to establish the BAC curve and to determine when the subjective ratings and free-pour assessments should be completed (Marczinski & Fillmore, 2009). The instrument is approved by the National Highway Traffic Safety Administration and meets criteria for evidential use by law enforcement for in-field alcohol testing.

Free-pour volume. For each free-pour, participants were provided a clear pitcher filled with four cans of beer and a clean, 16oz clear plastic cup to pour in to. Free-pour volume was

measured as total fluid ounces using a Taylor® digital measuring cup, which has been used in previous studies examining the effect of pour training with college students (Metz et al., 2017).

Subjective impairment. A modified visual analog scale (VAS) utilizing a 90-mm horizontal line was used to assess participant's rating of subjective impairment (Bernosky-Smith et al., 2011). Participants were asked to draw a vertical line along the VAS to indicate their response to the prompts "I feel intoxicated" and "I'm confident my free-pour was a standard drink." Responses were recorded as the distance in millimeters from the left edge of the scale to the intersecting line drawn by the participant. The left edge of the scale represents "not at all," and the right edge represents "extremely." The VAS is a well-established measure to assess subjective impairment with adult drinkers (Fillmore & Weafer, 2012; Ostling & Fillmore, 2010).

Procedure

Online screening. Prior to completing the screening questionnaire, participants saw an online version of the informed consent form. Participants were informed that by continuing to the survey, they were providing their consent to participate. Participants then proceeded to the online measures that included demographic and medical history questions, the AUDIT, and the RAPI. Following the survey, participants were shown a list of mental health providers and provided a link to information about college student drinking for their reference. After completion of the online questionnaire, participants were thanked for their time and informed that they would be contacted within three weeks to schedule a laboratory session if they were selected.

Selected participants received an email with instructions to schedule a laboratory session via the online SONA system. This email also informed interested participants of procedures for the laboratory session. Specifically, the email informed interested participants that the laboratory

session may involve the voluntary consumption of alcohol, was expected to last approximately 3.5 to 6 hours, and that participants would be compensated with up to 7 hours of additional extra credit and a chance to win a $50 gift card via raffle. Further, the email informed interested participants that they should consume breakfast but refrain from eating approximately four hours prior to the session, as well as refrain from drug or alcohol use in the 24 hours prior to their scheduled session. Participants were reminded that they must be 21 years or older to participate, and that their age would be verified during the session. Finally, participants were informed that free food, non-alcohol beverages, and entertainment would be provided.

Laboratory session. Once participants scheduled an appointment on the online SONA system, they were randomly assigned to an alcohol dose (n = 7) or placebo (n = 6) group. Upon arrival to the laboratory, participants were given a breathalyzer test to confirm that no alcohol was in their system, as well as asked if they have used any recreational drugs in the past 24 hours. Additionally, participants were asked the time of their last meal prior to dosing (see Table 2 for mean fasting periods). Following completion of the breath test, a research assistant provided the participants with an informed consent for the laboratory portion of the study, confirmed results from the screening questionnaire (i.e., confirmed that the participant did not have any psychological or physical ailments, did not take any prescription medications that may interact with alcohol, and was not pregnant or planning pregnancy), and confirmed the participants age via state ID or passport. Participants were reminded that they were free to withdraw their consent at any time without penalty or loss of benefits. Participants were then weighed and completed the free-pour training procedure followed by the remaining portions of the session.

Pour training. To increase the likelihood that differences in pouring behavior across time-points were due to intoxication and not practice effects, participants were trained to pour a standard drink of beer within 10% of a standard drink size prior to alcohol dosing. Free-pour training was be modeled after the Stimulus Fading condition utilized by Metz and colleagues (2017). Using this training technique, participants poured a standard drink of beer from a pitcher containing light beer into three 16 oz clear cups (without grooves) with various weighted lines. The first cup had solid line around the exterior of the cup that corresponded with a 12oz pour; similar to the first cup, the second cup had a thick dashed line at 12oz, and the third cup had a thin dashed line at 12oz. For the solid lined cup, participants were told "This line represents a standard drink of beer. Please pour a standard drink of beer into this cup." If participants poured within 10% of 12 oz, they moved to the next cup. Upon presentation, the participant was asked to "Please pour a standard drink of beer into this cup." This process was repeated with the final cup. If participants poured within 10% of the standard for each cup, they completed training by pouring into a cup with no lines. Participants were considered trained if two consecutive pours into the unmarked cup fell within the 10% criteria. If participants' pours into the unmarked cup fell outside of the 10% criteria on two consecutive training trials, the previous stimulus prompt was delivered and the above process was repeated until criteria was met. The two criterion free-pours (i.e., free-pours in the unmarked cup that fall within 10% criteria) were averaged to create a composite baseline free-pour score.

Dosing procedure. Once participants met the free-pour training accuracy criteria and completed the subjective measures, participants received a dose of 0.65 g/kg (grain alcohol) or 0.0 g/kg (placebo) sufficient to raise their BAC to a target range of 0.061% to 0.069% (average of 0.065%, average peak of 0.08%; Holland & Ferner, 2017; Marczinski & Fillmore, 2009).

Alcohol doses were determined by the participant's body weight. Dose administration was completed in a double-blind fashion, such that the research assistant administering the dose was blind to whether the dose was alcohol or placebo. The alcohol dose was divided into two drinks containing one part absolute alcohol mixed with three parts orange juice. Placebo drinks were divided into two drinks and contained the same total volume as the alcohol drinks, and approximately 3 ml of alcohol was floated on the surface to replicate the smell and taste of the alcohol drinks. The two drinks were served five minutes apart, and participants were asked to consume each drink within a minute (Marczinski & Fillmore, 2009). Previous research has demonstrated that this procedure is expected to produce an average BAC of 0.065% in approximately 30 minutes and an average peak BAC of .08% in approximately 60 minutes (Marczinski & Fillmore, 2003; 2005). It was also expected that BAC would begin to decline at approximately 75 minutes, with an average BAC of 0.065% at 90 minutes (i.e., descending limb BAC). This procedure was chosen based on previous research demonstrating behavioral impairment at this BAC (Harrison & Fillmore, 2005; Marczinski & Fillmore, 2009).

Post-dose measurements. Among the alcohol dose group, repeated assessment of subjective impairment and free-pour accuracy were conducted when participants reached the target BrACs on the ascending and descending limbs (0.061% to 0.069%). For four of the seven participants in the alcohol dose group, the target BrAC on the ascending limb was missed – three participants had a BrAC that exceeded the target range (001 [0.070%; minute 20], 008 [0.076%; minute 40], 012 [0.079%; minute 20]), and one participant (005) had BrAC readings that peaked at 0.042 and thus never reached the target range. For participants whose BrAC exceeded the target range, repeated measures were obtained at the timepoint corresponding to when the values reported above where obtained. For Participant 005, the repeated measure corresponding to the

ascending limb was taken at minute 30 (0.040%), as the previous reading was indicative of an abnormal BrAC curve (i.e., the BrAC at minute 20 was higher than minute 30; see Figure 4 for details). Of the seven participants in the alcohol dose group, on the descending limb, the target BrAC was missed for two participants (005 [0.040%; minute 70] and 015 [0.049%; minute 70]). For these participants, repeated assessment was conducted at the timepoint following the assumed BrAC peak (See Figure 4 for details on BrAC curves). Among the placebo dose group, repeated assessment of subjective impairment and free-pour accuracy was yoked to the dose group.

At the determined timepoints for repeated assessment, participants were first given the pitcher with light beer and the 16 oz clear cup with no lines and were asked to "Please pour a standard drink of beer." Following completion of the free-pour, participants were given the VAS measure and asked to draw a vertical line along to indicate their response to the prompts "I feel intoxicated" and "I'm confident my free-pour was a standard drink."

Session completion. Participants were required to stay in the laboratory for approximately three to five hours after consumption of their dose. The room was equipped with a computer with internet and video streaming access and a comfortable chair to sit in. Snacks and beverages were also available to consume once participants completed the descending limb repeated measures. After completing the repeated measures, participants provided a blood alcohol content reading (BrAC) via a calibrated breathalyzer every 5-20 minutes until their BrAC returned to 0.002% or less, which is within the range of no alcohol existing in an individual's body. Of the 13 participants, three participants in the alcohol dose group requested to terminate the session early, but after completion of all repeated measures. In these instances, the research assistants initiated the IRB approved emergency protocol. The emergency protocol

included reminding participants of the consent form and encouraging them to continue with the study until their BrAC returned to zero. If this was unsuccessful, the participant was asked to call a ride. If the participant could not establish a ride and if both research assistants were in agreement that the participant was not showing signs of impairment (e.g., reduced BrAC, no behavioral indicators in impairment), the participant was allowed to leave on their own. In all cases, the participant was informed of the dangers of terminating the session with a BrAC above zero, and was asked to signed an informed release form indicating they understood those risks.

Data Analysis Plan

A priori analyses conducted using G*Power (version 3.1.9.2; Faul, Erdfelder, Lang, & Buchner, 2007) suggested the sample size required for mean group comparisons was at least 18 people to detect significance with a power of .8 and medium effect size (Amlung et al., 2014; Weafer & Fillmore, 2012). Results of a power analyses conducted on a series of 2 (dose: 0.0 g/kg vs. 0.65 g.kg) by 3 (time: baseline, ascending limb, descending limb) mixed design analysis of variance (ANOVA), in which dose was the between-subjects factor and time was the within-subjects factor, indicated that two of the four models were underpowered. Specifically, the 2x3 ANOVA to examine differences in free-poured volume, and the 2x3 ANOVA to examine differences in subjective ratings of accuracy, the two dependent variables that have not been previously examined in acute tolerance research and are of primary interest in the current study, indicated power well below the suggested threshold of 0.80. In contrast, the results of the 2x3 ANOVA to examine differences in BrAC and subjective impairment were sufficiently powered (ANOVA data not reported).

Given the small sample size and associated limited power for the primary variables of interest, data for each hypothesis are described in a manner consistent with single subject

research designs and previous studies examining the effect of training on pouring behavior (Hankla, Kohn, & Normand, 2017; Metz et al., 2017; Kohn et al., 2017). This technique consists of visually analyzing individual data points to identify potential trends in data following the introduction of the independent variable (Cooper, Heron, & Heward, 2007). Thus, for the purposes of the current study, results will be reported as the percentage of participants whose data follow specific trends in relation to the proposed hypotheses. Also consistent with single-subject data analysis (Cooper et al., 2007), free-pour accuracy results are also described as the percentage of participants whose pours remained within the 10% training criterion, as this criterion has previously been established in free-pour training research (Hankla et al., 2017; Metz et al., 2017); no criterion were identified for subjective impairment measures.

Results

Online Survey Measures

Table 1 shows the means and standard deviations of responses to the online survey measures collected prior to laboratory sessions by group. On average, participants in both conditions were frequent drinkers, with multiple episodes of binge drinking in the 28 days preceding the survey. On average, participants in the alcohol dose group had scores on the AUDIT above the recommended cutoff, suggesting patterns of hazardous or harmful use. As stated above, any analysis of group differences should be interpreted with caution due to the small samples size and limited power. However, it is worth nothing that the participants in the alcohol dose group reported higher level of alcohol use and more negative consequences associated with alcohol use.

Free-Pour Training

Figure 2 shows the result of the free-pour training procedure for participants in the alcohol dose group. In the alcohol dose group, four (57%) participants poured within 10% of a standard drink of beer at baseline. The remaining three participants (43%) under-poured at baseline. Of the seven participants in this condition, three (43%) completed the free-pour training with no additional training trials (i.e., met training criteria at each pour, for a total of six pours). One participant (14%) completed free-pour training with no additional training trials, but with four pours in the unmarked test cup (8 pours total). Of the remaining participants, one (14%) completed training after returning to the thinned line stimulus cup once (9 pours total), one (14%) completed training after returning to the thinned line stimulus cup twice (12 pours total), and one (14%) completed training after returning to the thinned line stimulus cup three times (15 pours total). Although some variation existed across number of training trials, all seven participants were able to meet the training criteria by completing two consecutive pours within 10% of a standard drink of beer.

Figure 3 shows the result of the free-pour training procedure for participants in the placebo dose group. In the placebo dose group, two (33.3%) participants poured within 10% of a standard drink of beer at baseline. The remaining four participants (66.7%) under-poured at baseline. Of the six participants in this condition, four (66.7%) completed the free-pour training with no additional training trials (i.e., met training criteria at each pour, for a total of six pours). Of the remaining participants, one (16.7%) completed training after returning to the thinned line stimulus cup once (9 pours total), and one (16.7%) completed training after returning to the solid line stimulus cup once (16 pours total). Similar to the alcohol dose group, all six participants were able to meet the training criteria by completing two consecutive pours within 10% of a standard drink of beer.

Dosing

Table 2 shows the results of BrAC measures taken at each timepoint of the BrAC curve (or yoked timepoint in the placebo dose group) following the dose. As expected, participants in the alcohol dose group had BrAC measures significantly higher than the placebo dose group at each timepoint. On average, participants in the alcohol dose had BrAC measurements that were similar and within the target range on the ascending and descending limb. The average peak BrAC also suggests that the alcohol dose sufficiently increased participants' BrAC to a range indicative of behavioral impairment. However, analysis of individual data suggests variation in BrAC curves, in addition to some individuals achieving higher or lower peaks than expected (see Figure 3).

Hypothesis 1: Free-Pour Accuracy

Figure 4 shows the results of free-poured volumes along the BrAC for each participant in the alcohol dose group. Visual inspection of the data suggests that the hypothesized increase in free-pour volume at Times 2 and 3 only occurred for two of seven (28.6%) participants (001, 006). In contrast, two participants' (28.6%; Participants 002 & 005) data showed a slight decrease at Time 2 compared to baseline, with Time 3 pours matching or exceeding baseline free-pours. One participant (14.3%; Participant 008) had a pour at Time 2 that was larger than their pour at baseline, but subsequently decreased below baseline at Time 3. One participant (14.3%; Participant 015) had a free-pour at Time 2 that was consistent with baseline, but subsequently decreased at Time 3. Finally, one participant (14.3%; Participant 012) showed a gradual increase in free-poured volume over time. In addition to visual inspection to analyze the hypothesis of free-pour accuracy, free-pours were evaluated in terms of whether or not they met the original training criteria. Out of the total 14 pours completed at Time and Time 3, only two

(14.2%; Participants 002, 015) were outside of the 10% training criteria (one at each timepoint)– both were under-pours. Together, these findings appear to be inconsistent with the proposed hypothesis; given the low variability in free-pours and that the vast majority were within the training criteria, there appears to be no meaningful effect of dose on free-pour accuracy over time.

Figure 5 shows the results of free-poured volumes along the BrAC for each participant in the placebo dose group. Visual inspection of the data suggests that two of six participants (33.3%; Participants 003, 004) had free-pours that were the same at baseline and Time 2; however, at Time 3, Participant 003's pour volume slightly increased, while Participant 004's pour volume slight decreased. For two other participants (33.3%; Participants 010, 014) free-pour volumes decreased compared to baseline at Time 2, but increased beyond baseline at Time 3. One participant's (16.7%; Participant 013) pours at Time 2 and 3 were lower than baseline, but Time 3 was slightly larger than Time 2. Finally, one participant (16.7%; Participant 011) showed a slight increase in pouring at Times 2 and 3, with the Time 3 pour slightly less than Time 2. In addition to visual inspection to analyze the hypothesis of free-pour accuracy, free-pours were evaluated in terms of whether or not they met the original training criteria. Out of the total 12 pours completed at Time 2 and Time 3, only two (16.7%) were outside of the 10% training criteria – both were at Time 2 and both were under-pours.

Table 3 shows the means and standard deviations of free-poured volumes at each time for the alcohol dose and placebo dose groups. Mean data are consistent with visual data suggesting that, overall, participants' free-pours in both groups were fairly consistent with a standard drink of beer over time (i.e., within 10%). Thus, there appears to be no meaningful between subjects differences, nor any interactions related to dose or time. Individual data also highlight that any

group comparisons should be interpreted with caution, as few participants data were consistent with the anticipated relation between dose and time.

Hypotheses 2 and 3: Subjective Impairment

Subjective Intoxication. Figure 6 shows the results of the VAS for subjective ratings of intoxication along the BrAC for each participant in the alcohol dose group. Consistent with the hypothesis, visual inspection of the data suggests that all seven (100%) participants' ratings of subjective intoxication were higher at Time 2 compared to Time 3; Time 3 ratings were also higher than Time 1, but were lower Time 2 (effect consistent with acute tolerance).

Figure 7 shows the results of the VAS for subjective ratings of intoxication along the BrAC for each participant in the placebo group. Visual inspection of the data suggests findings mostly consistent with the hypothesis. Four participants (66.7%; Participants 003, 004, 011, 013) had consistent ratings over time; one participant (16.7%; Participant 010) rated themselves as more intoxicated at Time 2 compared to Time 1 and Time 3 (trend consistent with a placebo effect), and one participant (16.7%; Participant 014) rated themselves as more intoxicated at Time 2 compared to Time 1, and more intoxicated at Time 3 compared to Times 1 and 2.

Table 3 shows the means and standard deviations for the VAS subjective ratings of intoxication at each time for the alcohol dose and placebo dose groups. Mean data are consistent with visual data suggesting that participants' ratings of intoxication at Time 1 were similar across groups. Also consistent with the hypothesis, participants' ratings of intoxication in the alcohol dose group were larger than ratings of intoxication in the placebo dose group at Times 2 and 3. Given the correspondence between visual data and mean data, there appears to be meaningful between subjects differences, as well as an interactions between dose and time.

Subjective Accuracy. Figure 6 shows the results of the VAS for subjective accuracy of free-pours along the BrAC for each participant in the alcohol dose group. Visual inspection of the data showed findings inconsistent with the hypothesis. Of the seven participants, three (42.9%) participants' data followed the hypothesized trend (Participants 001, 008, 015), in that their ratings of accuracy fell at Time 2, and slightly increased at Time 3 but remained lower than Time 1. One participant (14.2%; Participant 002) showed a gradual decrease in ratings of accuracy at each time point, whereas a different participant (14.2%; Participant 012) showed a gradual increase in ratings of accuracy at each time point. In contrast to the hypothesis, one participant's (14.2%; Participant 005) ratings of accuracy were lowest at baseline and highest at Time 2. Finally, one participant's (14.2%; Participant 006) ratings of accuracy decreased at Time 2, but increased above baseline ratings at Time 3.

Figure 7 shows the results of the VAS for subjective accuracy of free-pours along the BrAC for each participant in the placebo group. Visual inspection of the data suggests that five of six (83.3%) participants showed a slight gradual increase across time points in their ratings of subjective accuracy (Participants 003, 004, 010, 013, 014). In contrast, one participant (16.7%; Participant 011) rated themselves as more accurate at Time 2 compared to Time 1, but their rating decreased below baseline Time 3.

Table 3 shows the means and standard deviations for the subjective ratings of free-pour accuracy at each time for the alcohol dose and placebo dose groups. Inconsistent with the hypothesis, participants in the placebo dose group rated their level of accuracy slightly lower at Time 1 compared to the alcohol dose group. Also inconsistent with the hypothesis, ratings of accuracy were similar across groups at Times 2 and 3. Together, these findings suggest no meaningful between subjects differences, nor any interactions between dose and time. However,

individual data highlight that any group comparisons should be interpreted with caution, as few participants data in the alcohol dose group were consistent with the anticipated relation between dose and time.

Discussion

The current study was the first to examine the relationship between intoxication, free-pouring behavior, and subjective impairment among a sample of college students engaging in high-risk alcohol consumption. Consistent with previous findings and the Mellanby effect (Holland & Ferner, 2017), visual data suggest that participants who received a dose of alcohol showed acute tolerance on ratings of subjective impairment, indicating feeling less intoxication on the descending limb of the BrAC in comparison to the same BrAC on the ascending limb. However, visual data suggest that inconsistent with hypotheses, free-poured ounces and subjective ratings of free-pour accuracy were not subject to acute tolerance. Rather, despite clear elevations in BrAC and ratings of intoxication, individuals in the alcohol dose group continued to pour beer volumes consistent with a standard drink size on the ascending and descending limbs; further, these free-pours were consistent with pours from participants in the placebo dose group, suggesting no meaningful effects of dose, time, or an interaction between dose and time. Consistent with the findings related to free-pour accuracy, participants' ratings of free-pour accuracy in the alcohol dose group remained stable across the BrAC curve; ratings of perceived accuracy in the placebo dose group were similarly stable, suggesting no meaningful effects of dose, time, or an interaction between dose and time.

The finding that measures of free-pour accuracy were not subject to acute tolerance appears to be consistent with findings that cognitive and behavioral tasks are likely differentially subject to the effects of acute tolerance (Moskowitz et al., 2000). However, in contrast to

previous studies examining acute tolerance, results from the current study included baseline measures to compare to ascending and descending ratings (Holland & Ferner, 2017). In the current study, results suggesting that measures of free-pour accuracy did not change from baseline to the ascending limb provides an explanation for why the effect of acute tolerance was not observed; specifically, no improvement on the descending limb could be observed, as no deterioration on the ascending limb was observed. While this provides initial evidence that behavioral skills training can minimize the negative effects of impairment on the ascending limb, future studies should examine if the effect of acute tolerance exists in the absence of training.

Relatedly, the finding that ratings of subjective accuracy were stable across groups and times, whereas ratings of subjective intoxication were not, may provide further evidence that behavioral skills training may weaken the relationship between intoxication and subjective impairment. Specifically, an individual's perception of their ability to perform a task may be directly linked to their behavioral knowledge. However, conclusions regarding this effect are limited as participants did not complete ratings of subjective accuracy following the completion of their pre-training free-pour; thus, it is unknown if subjective accuracy improved following the receipt of training. Future research should systematically examine the relations between other trained protective behavioral skills (PBS; e.g., drink refusal, drink counting), subjective ability, and various levels of intoxication (including baseline abilities) to examine if acute tolerance is weakened following behavioral skills training.

While the hypotheses related to actual and perceived free-pour accuracy were not supported, findings from the current study are consistent with previous studies (Hankla et al., 2017; Metz et al., 2017) suggesting that the free-pour training procedure is a simple, efficient tool to teach a behavioral skill that may aid in alcohol risk reduction. Specifically, this study

expands previous findings (Hankla et al., 2017; Metz et al., 2017) by showing that free-pour training persists despite intoxication consistent with behavioral impairment (Harrison & Fillmore, 2005; Marczinski & Fillmore, 2009), which has important clinical implications related to harm reduction.

Alcohol education courses and brief interventions often include psychoeducation and PBS training to reduce risk associated with heavy alcohol consumption (e.g., Dimeff, 1999; Haines, Barker, & Rice, 2006; Ray, Stapleton, Turrisi, & Philion, 2012; Carey, Scott-Sheldon, Carey, & DeMartini, 2007). In particular, these harm reduction strategies focus on teaching individuals standard drink definitions to improve one's ability to count standard drinks and thus reduce risky alcohol consumption. While this is an important first step, previous research has demonstrated clear discrepancies between individuals free-poured drink sizes and their estimates of the volume poured (Schultz et al., 2017), suggesting that prevention and intervention efforts aimed at only increasing verbal knowledge may be insufficient. Thus, behavioral skills training aimed at improving an individual's ability to pour standard drinks could improve personalized feedback interventions (PFI) aimed at reducing alcohol related risk. Specifically, the provision of free-pouring training in PFI could provide experiential education that can be directly linked to BAC and thus reduce the risk of alcohol-related consequences (Schultz et al., 2017). Future studies should examine the feasibility of incorporating free-pour training into PFI.

While the findings from the current study are limited to free-pour accuracy, they provide promise for the feasibility of behavioral skills training for other PBS, given some of the inconsistency in their efficacy (Prince, Carey, & Maisto, 2013). In a qualitative study examining students' beliefs about PBS, participants expressed interest in specific knowledge and skills to reduce alcohol-related risk, such as drink refusal skills, peer pressure, and alcohol toxicity

(Howard, Griffin, Boekeloo, Lake, & Bellows, 2009). Thus, similar to alcohol education and brief interventions aimed at improving standard drink knowledge, PBS interventions may be limited by 1) their didactic versus experiential nature, and 2) their proximity to the drinking context. In other words, PBS interventions may be more effective when a specific behavior is trained and the training more closely replicates the context in which the requisite skill is required. Thus, future studies should examine whether the current findings are replicable among other PBS by testing performance after the introduction of alcohol. Considering the strong relationship between intoxication and risky decision making (e.g., driving while intoxicated; Bernosky-Smith et al., 2011; Marczinski et al., 2008; Marczinski & Fillmore, 2009), another approach may be to provide individuals with real-time feedback on their BAC in the context of decision-making or performing a task. For example, participants given feedback on their driving performance in relation to their BAC after receiving a dose of alcohol reported fewer instances of drinking after driving 8 months later (Howat, Robinson, Binns, Landauer, & Palmer, 1991). While these follow-up data are self-report, they provide some evidence that direct, proximal feedback on the relation between a behavior associated with alcohol risk and training specific to that behavior (i.e., the effect of elevated BAC on performance) can reduce alcohol related consequences. Future studies should examine whether feedback on skill performance and subjective impairment in relation to an individuals' BAC reduces alcohol related consequences.

While findings from the current study suggest that behavioral skills training to free-pour a standard drink of beer can persist despite levels of intoxication consistent with behavioral impairment, there are several limitations that warrant mention. First, the sample size was small, limiting the ability to conduct inferential statistics. While the final sample consisted of 13 participants, nearly 400 potential participants completed the online screening survey,

highlighting some of the difficulties associated with conducting alcohol administration studies, particularly in a university setting. For example, to ensure the safety of participants given the moderate dose of alcohol, the inclusion criteria were necessarily stringent (Silvestri, Lewis, Borsari, & Correia, 2014). Further, participation in the study was quite time intensive, which likely limited individuals' ability to participate (as evidenced by the 28% conversion rate from invitation to participation). Despite the small sample size, analyses of visual data suggested a clear effect of acute tolerance on subjective impairment; all seven participants in the alcohol dose group had data consistent with this effect. In contrast, individual data for the effects of intoxication on actual and perceived accuracy showed more variability, with few participants in the alcohol dose group having data consistent with the hypotheses. While these findings are indicative of no meaningful effect of alcohol on actual and perceived free-pour accuracy in the current sample, future studies should examine these effects with a larger sample.

Second, to minimize the effects of cup color and cup lines, a clear, 16 oz generic plastic cup with no lines was selected. While using this cup improved feasibility and ensured that correct free-pouring behavior was the result of training, it likely restricted variability, and any potential over-pours may have been minimized. This is consistent with previous findings suggesting a positive, linear relationship between free-poured standard drinks and cup size (White et al., 2003). Thus, future studies should examine potential effects of intoxication on free-pour behavior in a variety of cup shapes and sizes, such as cups with and without lines, and cups of varying shapes and colors. For example, consistent with Metz et al. (2017), the generalizability of the procedure could be accomplished by training and testing participants with one style of cup, but also including a similar but distinct generalization cup.

Third, data on the feasibility of free-pour training in currently restricted to training a standard drink of beer, which appears to be the alcohol that is least inaccurately poured in free-pour studies, particularly those that assess standard drink knowledge (Schultz et al., 2017). Consistent with previous free-pour studies assessing standard drink knowledge, nearly half of participants (46.2%) poured within 10% of the training criteria – the remaining participants under-poured. Previous studies have demonstrated similar trends – when asked to pour a "typical drink," participants poured larger than standard drink sizes for beer, whereas participants poured smaller than standard drink sizes for beer when asked to pour a "standard drink" (de Visser, 2015; de Visser & Birch, 2012). These findings suggest that the type of prompt has a differential effect on pouring behavior. Thus, the findings from the current study should be limited to knowledge of standard drink sizes of beer. To better understand the effect of intoxication on free-pouring behavior, future studies should examine if pouring behavior changes along the BrAC when participants are not trained to pour a standard drink, and rather are prompted to pour their typical drink size. In addition to varying the prompt and utilizing variable cup sizes, future studies should evaluate the feasibility of pour training with other alcohol types such as wine and liquor.

Fourth, analyses of individual BrAC curves indicated variability, limiting conclusions that can be drawn about peak BrAC and the effect of acute tolerance. Specifically, Participant 005, 006, 008, and 012's BrAC curves showed two "peaks," such that the identified peak was followed by a decrease in BrAC readings, with a return to a similar level at a subsequent reading. Previous findings have shown variability in BrAC measurements due to differences in lung size, fluctuations in inhalation and exhalation, and measurement variability of the testing device itself (Hlastala & Anderson, 2007; Hlastala & Anderson, 2016; Jaffe, Siman-Tov, Gopher, & Peleg,

2013). Thus, while we attempted to minimize variations in breathing patterns by providing a prompt to "breathe slowly and steadily into the machine," we were unable to control for duration and intensity of inhalation and exhalation, which may have contributed to variable readings. Future studies should include more specific directions on how to breathe into the BrAC machine to mitigate these potential effects.

Finally, variability in BrAC curves existed across participants. Specifically, while the average peak BrAC (0.075), descending BrAC, and ascending BrAC in the alcohol dose group were close to or within the target ranges, variability occurred across participants. Five participants had one or more BrAC reading outside of the target range (0.061% to 0.069%) during the repeated measurement of free-pour volume and VAS scales, whereas two participants had both repeated measures within the target range. This suggests that some repeated measures may be less comparable, as the BrAC on the ascending and descending limb were somewhat inconsistent. To reduce this, future studies should consider more frequent (e.g., every 5 minutes) BrAC measures, particularly on the ascending limb, to ensure that measurements fall within the target ranges.

Similarly, while the average peak BrAC and target ranges of impairment on the ascending and descending limb (0.061% to 0.069) were consistent with previous studies suggesting behavioral impairment and acute tolerance (Harrison & Fillmore, 2005; Marczinski & Fillmore, 2009), future studies should consider whether higher doses of alcohol would produce the effect of acute tolerance on free-pour variables. While research suggests that behavioral impairment of cognitive and visual abilities occurs at BACs as low as 0.01-0.02%, there appears to be greater variability for psychomotor tasks; thus, an integrative task such as the free-pour may show impairment at higher doses, with peak BACs between 0.10% and 0.12%, and target

ranges in the 0.07% to 0.08% (Moskowitz et al., 2000). This appears to be partially supported by the finding that the three participants whose ascending BrAC reading exceeded the target range showed a slight increase in free-poured volume on the ascending limb, although not all three participants' data were consistent with the hypothesized trend. With increasingly elevated BACs, the effect of behavioral skills training may weaken, which would have further implications for prevention and intervention efforts. More specifically, feedback on the deterioration of specific skills could be provided in relation the BAC curve, similar to feedback in PFI that provide education on the physiological effects of alcohol at various BACs (Dimeff, 1999). Future studies should consider the examination of pouring behavior and other PBSs under higher BACs; however, given the safety concerns and feasibility issues associated with alcohol administration studies noted above, these studies may need to be conducted in medical settings in which risk associated with large doses of alcohol can be more closely monitored and addressed.

In conclusion, the findings from the current study replicate previous studies suggesting that individuals' perceptions of their intoxication are subject to acute tolerance. In contrast to this effect, actual and perceived free-pour accuracy does not appear to be subject to acute tolerance following the receipt of behavioral skills training to correctly pour a standard drink of beer. These findings have important implications for prevention and intervention efforts aimed at reducing alcohol-related risk, as it appears that behavioral skills training may mitigate acute tolerance and persistent despite intoxication. Future research should continue to examine this effect under varying conditions (e.g., with and without training; laboratory vs. natural environments; variety of cups), with wider ranges of alcohol doses, and with other PBS (e.g., drink refusal; counting drinks).

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Table 1

Comparison of alcohol dose and placebo dose groups responses to online survey measures

	Alcohol Group (n = 7)	Placebo Group (n = 6)
	M(SD)	M(SD)
DDQ		
# Days alcohol use	9.86 (4.41)	6.50 (2.81)
# Days drunk	8.14 (5.27)	4.67 (3.20)
# Days binge	6.57 (4.76)	3.12 (2.56)
# Drinks on heaviest drinking day	11.00 (3.16)	7.50 (4.28)
AUDIT	13.57 (6.16)	6.50 (2.59)
RAPI	8.00 (7.05)	2.43 (0.99)

Table 2
BrAC data for each group at each timepoint of the BrAC curve

	Alcohol Group (n = 7)	Placebo Group (n = 6)
	M(SD)	M(SD)
Peak BrAC	0.075% (0.02%)	0.002% (0.004%)
Ascending BrAC	0.065% (0.01%)	0.00% (0.00%)
Descending BrAC	0.061% (0.01%)	0.00% (0.00%)
Time since last meal	333.43 (211.84)	261.83 (73.27)

Note. Time reported in number of minutes.

Table 3

Means and standard deviations for free-pour accuracy and ratings of subjective impairment

	Alcohol Group (n = 7)	Placebo Group (n = 6)
	M(SD)	M(SD)
Free-Pour Accuracy		
Time 1	11.15 (0.29)	11.41 (0.40)
Time 2	11.30 (0.45)	11.06 (0.61)
Time 3	11.27 (0.52)	11.67 (0.49)
Subjective Intoxication		
Time 1	0.32 (0.43)	0.25 (0.61)
Time 2	23.82 (9.27)	2.71 (4.45)
Time 3	17.0 (7.70)	2.88 (5.95)
Subjective Accuracy		
Time 1	70.43 (8.89)	63.25 (13.83)
Time 2	66.71 (8.50)	70.83 (12.65)
Time 3	69.71 (9.08)	70.00 (15.43)

Note. Time 1 refers to baseline (post-training); Time 2 refers to measures corresponding to the ascending limb; Time 3 refers to measures corresponding to the descending limb.

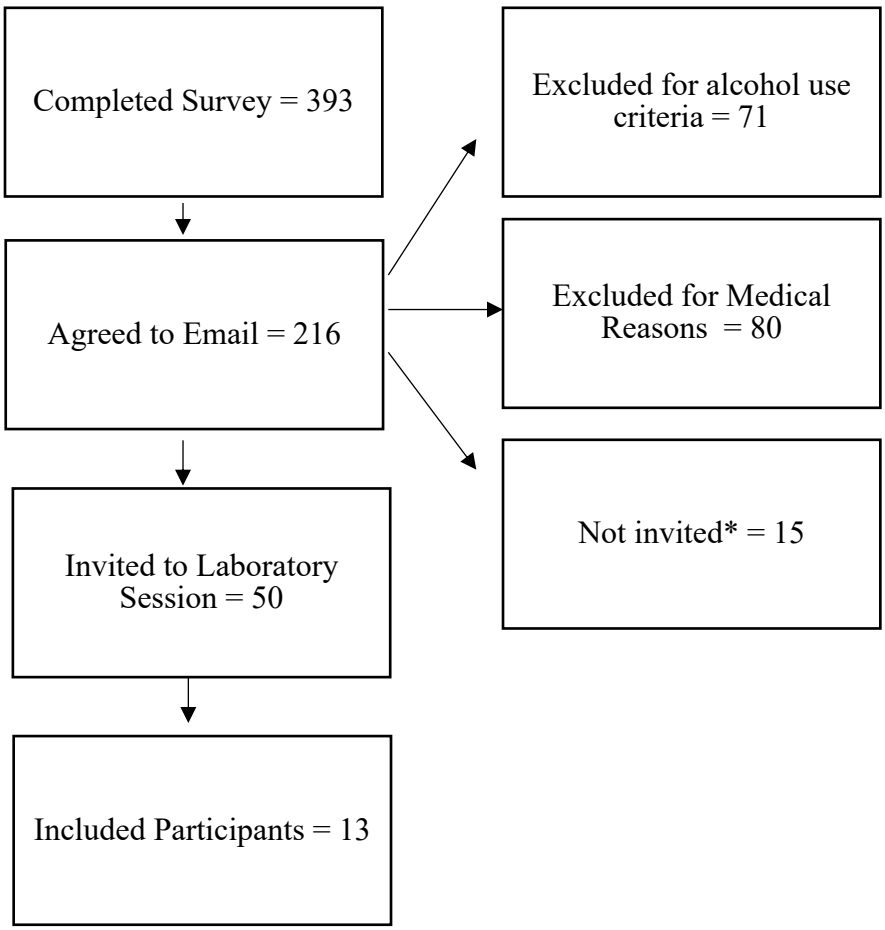

Figure 1. Flow of participants through study from screening to final inclusion. *Participants not invited due to end of semester and/or no remaining lab sessions available.

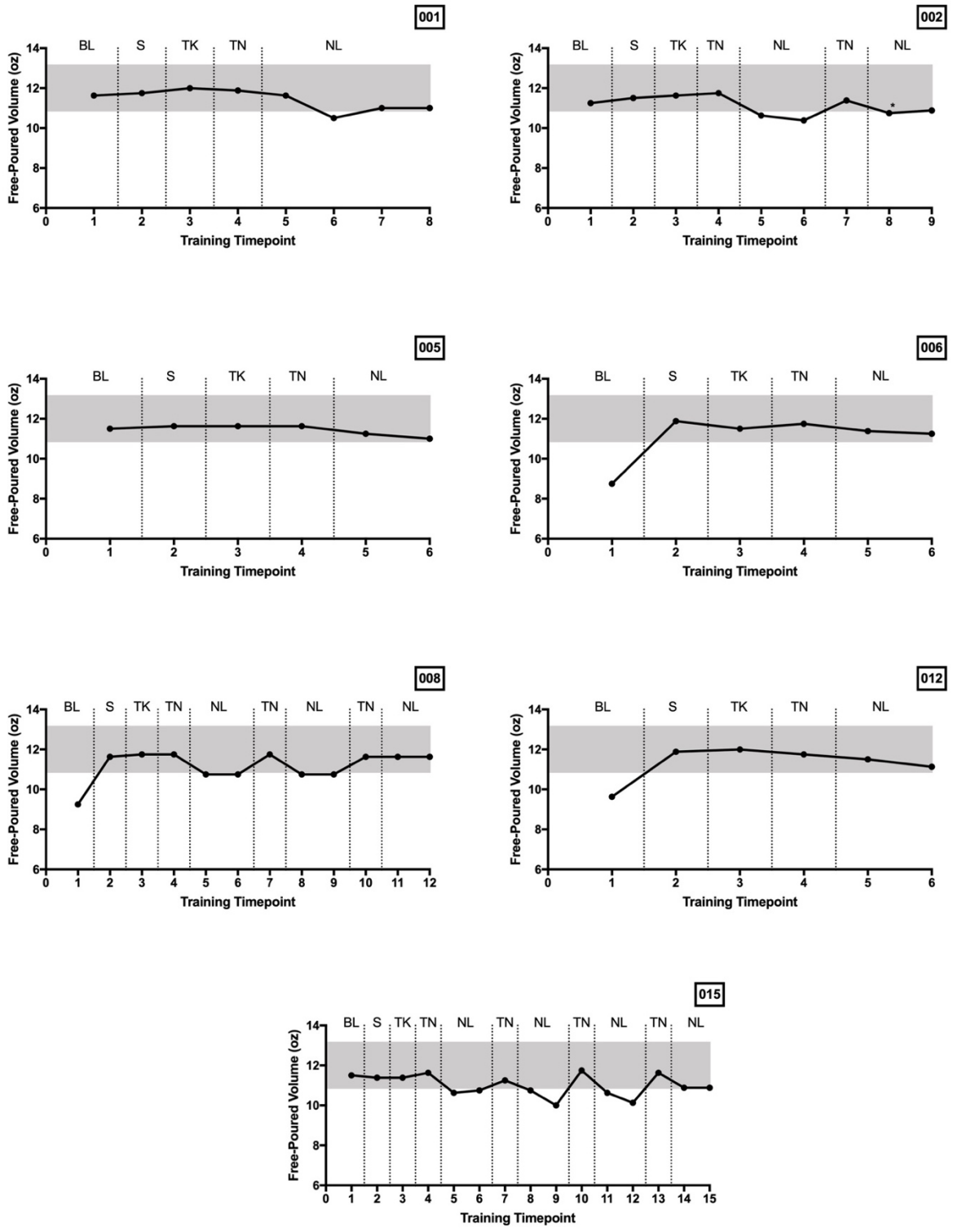

Figure 2. Results of free-pour training for participants in the alcohol dose group. The x-axis represents the training timepoint and the y-axis represents the amount free-poured in ounces. The gray area represents the 10% pour accuracy criterion (i.e., 10.8 oz to 13.2 oz). BL = baseline (no lines); S = solid lined cup; TK = thick lined cup; TN = thin lined cup; NL = no line cup.

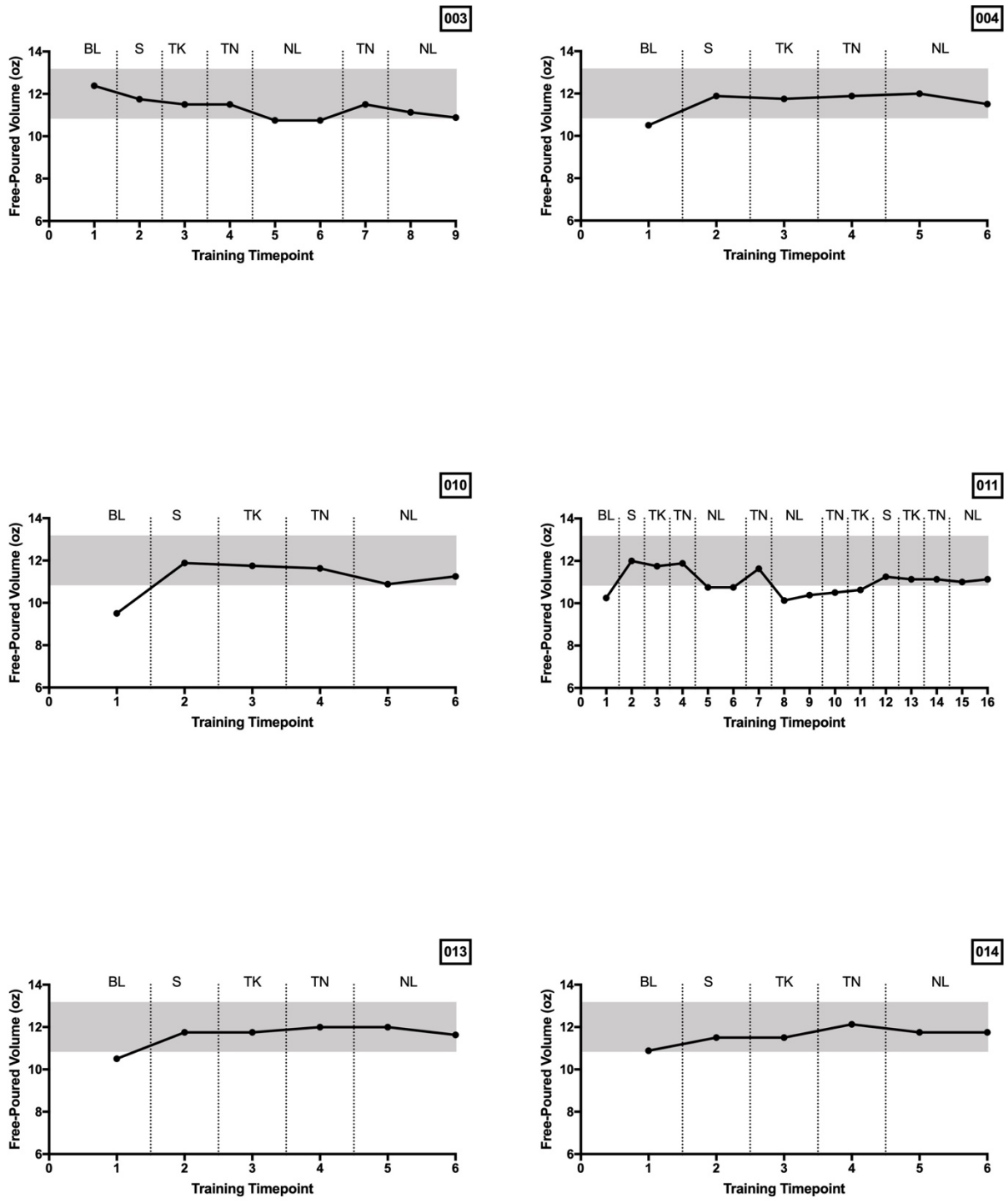

Figure 3. Results of free-pour training for participants in the placebo dose group. The x-axis represents the training timepoint and the y-axis represents the amount free-poured in ounces. The gray area represents the 10% pour accuracy criterion (i.e., 10.8 oz to 13.2 oz). BL = baseline (no lines); S = solid lined cup; TK = thick lined cup; TN = thin lined cup; NL = no line cup.

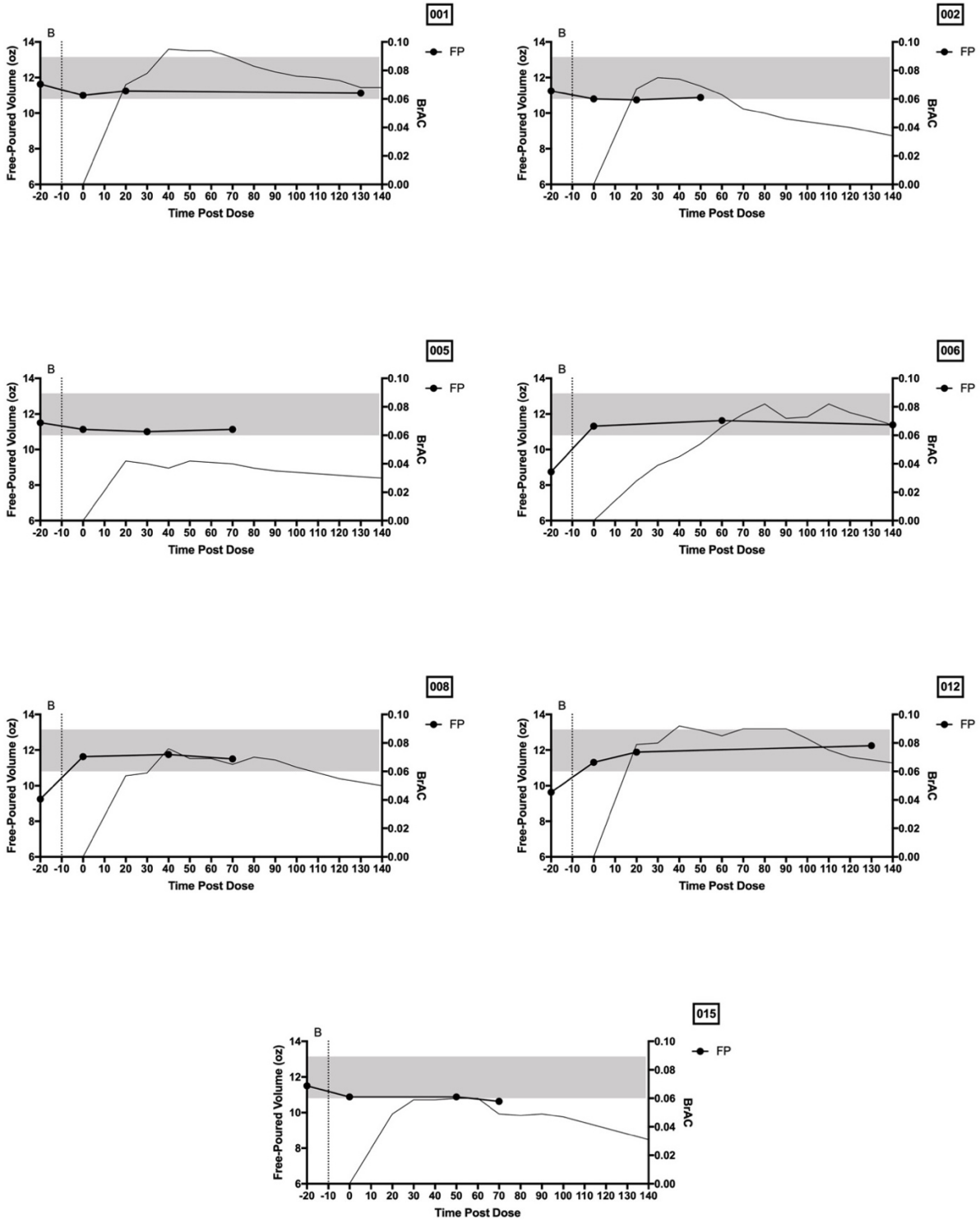

Figure 4. Results of free-pour accuracy for participants in the alcohol dose group. The x-axis represents the time post-dose, the left y-axis represents the amount free-poured in ounces, and the right y-axis represents BrAC readings. The gray area represents the 10% pour accuracy criterion (i.e., 10.8 oz to 13.2 oz). B = baseline (pre-training pour). The three subsequent data points represent Time 1, Time 2, and Time 3 pours.

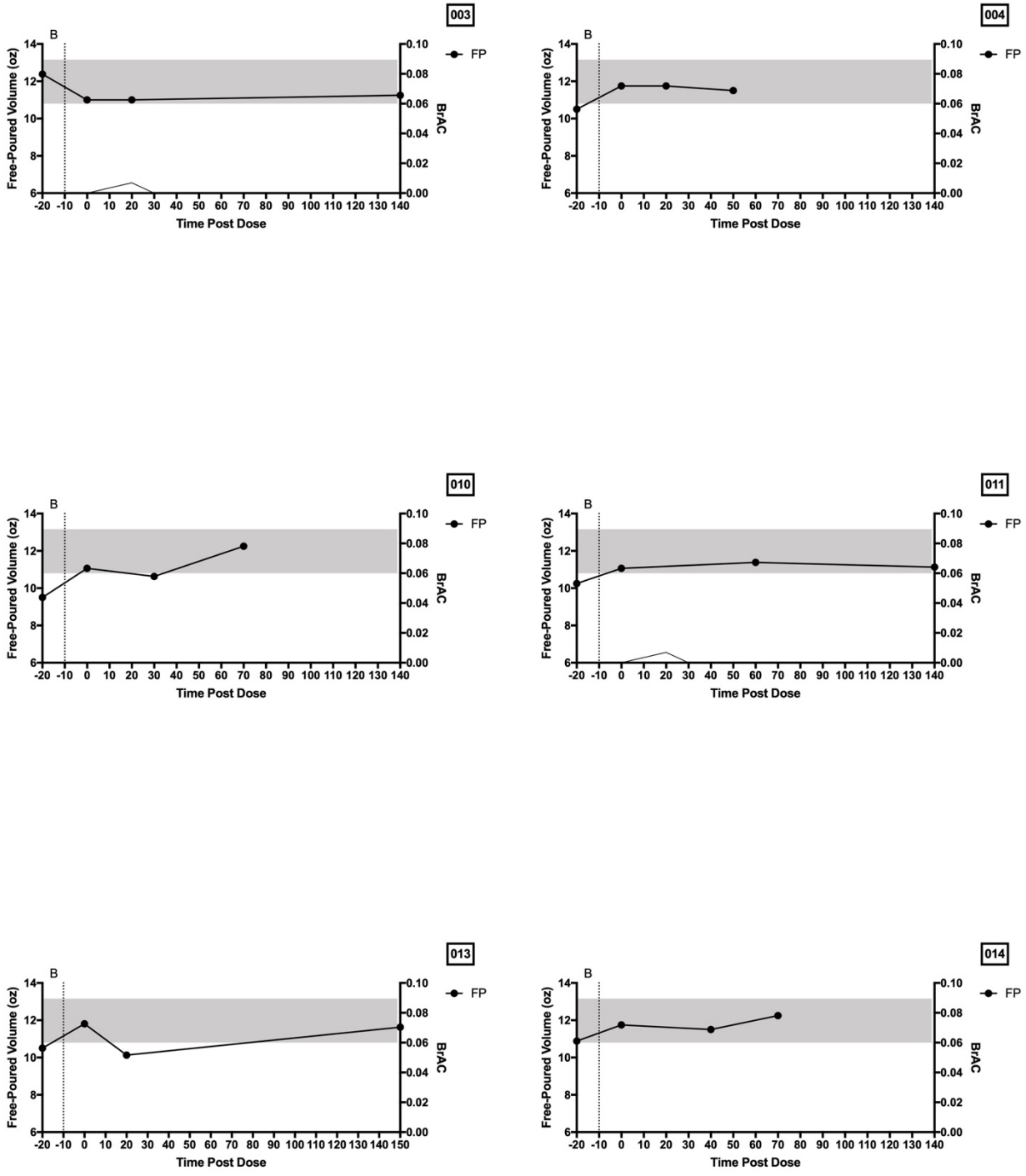

Figure 5. Results of free-pour accuracy for participants in the placebo dose group. The x-axis represents the time post-dose (yoked to alcohol dose group), the left y-axis represents the amount free-poured in ounces, and the right y-axis represents BrAC readings. The gray area represents the 10% pour accuracy criterion (i.e., 10.8 oz to 13.2 oz). B = baseline (pre-training pour). The three subsequent data points represent Time 1, Time 2, and Time 3 pours.

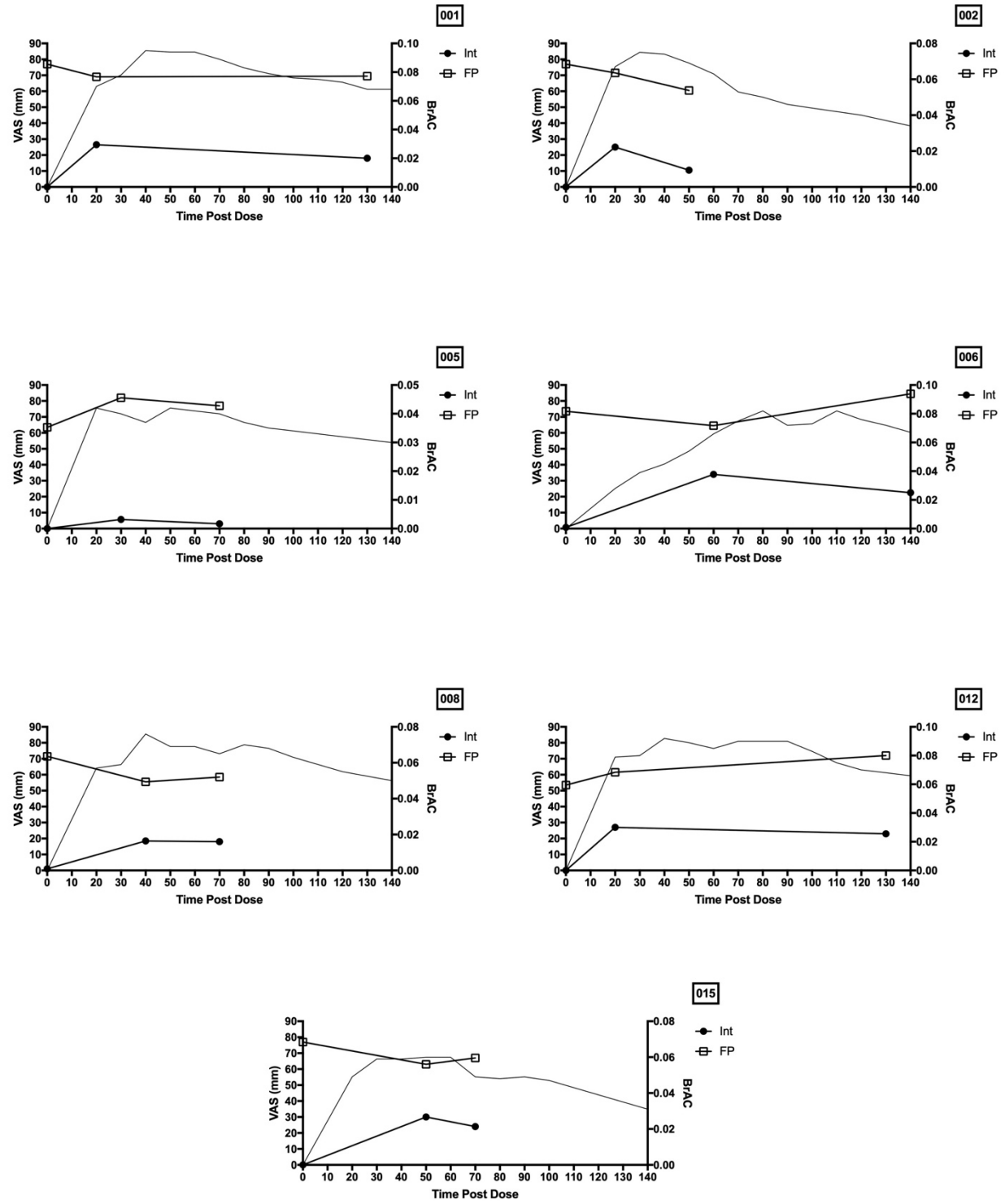

Figure 6. Results of ratings of subjective impairment for participants in the alcohol dose group at Time 1, Time 2, and Time 3. The x-axis represents the time post-dose, the left y-axis represents scores on the visual analog scale measured in millimeters, and the right y-axis represents BrAC readings. INT = ratings of subjective intoxication; FP = ratings of subjective accuracy.

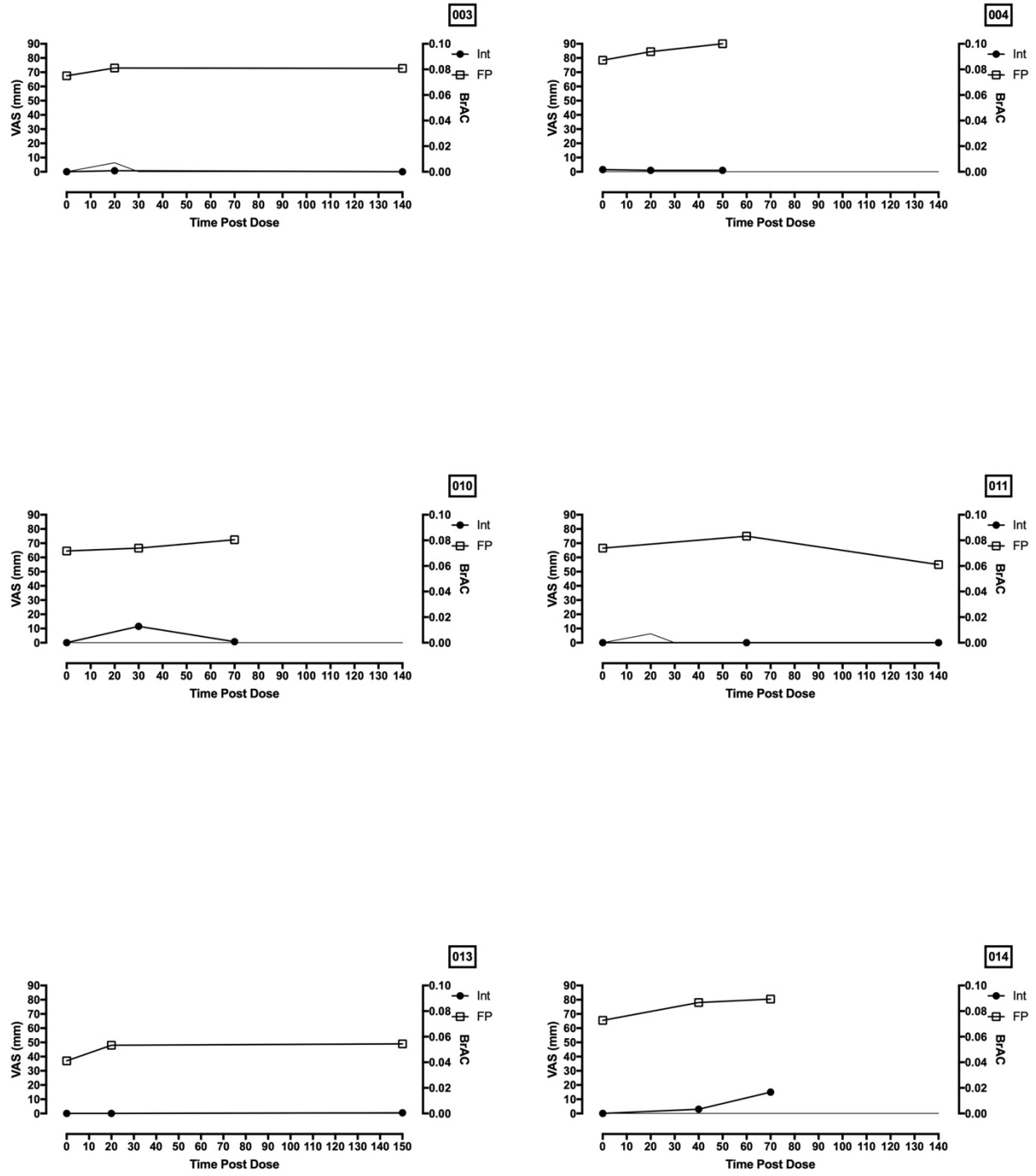

Figure 7. Results of ratings of subjective impairment for participants in the placebo dose group at Time 1, Time 2, and Time 3. The x-axis represents the time post-dose (yoked to alcohol dose group), the left y-axis represents scores on the visual analog scale measured in millimeters, and the right y-axis represents BrAC readings. INT = ratings of subjective intoxication; FP = ratings of subjective accuracy.