How people decide to consume (more) alcohol when feeling stressed

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Abstract

Background and Aims: The tension reduction hypothesis suggests that people consume alcohol to alleviate stress. While previous studies showed stress increases alcohol's absolute value, alcohol's value relative to alternatives should be more relevant for drinking decisions. We aimed to test whether acute stress causes individuals to choose alcohol over appealing non-alcoholic alternatives and to identify the cognitive mechanisms underlying this choice behavior.

Design: Laboratory-based randomized 2×2 experimental study.

Setting: Controlled laboratory environment including a simulated bar setting.

Participants: 160 adults (56% male; mean age=31 years; median AUDIT=8) who regularly consume alcohol.

Interventions: Participants first rated beverages and made repeated choices between alcoholic and non-alcoholic options. They then received either alcoholic beverages (target BrAC=.06%) or non-alcoholic beverages, followed by either a personalized stress induction using autobiographical emotional memories or a neutral control procedure.

Measurements: Primary outcomes were proportion of choices for alcoholic beverages and decision response times. Choice behavior was analyzed using drift diffusion modeling to decompose decisions into three mechanisms: decision carefulness (boundary parameter), sensitivity to prior preferences (drift rate), and bias toward alcohol regardless of preference (bias parameter).

Findings: Stress moderately increased choices for alcohol (95% HDI [0.01, 0.13]), but only in sober participants. Drift diffusion modeling revealed that stress primarily affected decision-making by inducing a bias toward alcohol during evidence accumulation (95% HDI [0.19, 0.76]), without impacting decision carefulness or evidence sensitivity. This computational bias was stronger than observed in raw choice behavior, indicating that while stress consistently biases evaluation toward alcohol, this bias only sometimes overcomes competing considerations (i.e., a person might reverse a preference from 'a little bit' to 'not really', but not from 'a little bit' to 'not at all').

Conclusions: Our results are relevant to adults who report risky drinking without alcohol treatment history or comorbidity and provide support for the tension reduction hypothesis by demonstrating that stress can occasionally lead individuals to choose alcohol even when they prefer the non-alcoholic alternative. However, this effect only appeared in sober participants who have not yet consumed any alcohol, suggesting the hypothesis primarily explains decisions about initiating rather than continuing drinking episodes.

Keywords: tension reduction hypothesis, stress, alcohol, value-based decision-making, Drift Diffusion Model

The notion that people consume alcohol to alleviate aversive states of psychological stress and negative emotions is one of the central ideas in the study of the etiology of alcohol use disorders (AUDs) (1–3) and variously called the *tension reduction* hypothesis (4), the *affect regulation* hypothesis (5), or the *self-medication* hypothesis (6). At its core, the hypothesis describes a within-person process, proposing that an individual is more likely to consume and consumes more alcohol in a stressful moment compared to a moment absent from stress. Indeed, approximately 90% of people who regularly drink alcohol report that they consume alcohol to reduce stress and to forget their worries at least some of the time (7).

Lab-based experimental research has generally supported the tension reduction hypothesis. Studies have shown that following inductions of stress or negative mood, people consume more alcohol (8), crave alcohol more (8,9), are willing to spend more money on alcohol (10–12), prefer alcoholic over non-alcoholic visual cues (13), and devalue non-alcoholic alternatives (14,15). However, ecological momentary assessment (EMA) studies in people's daily life have not supported the predictions made by the tension reduction hypothesis, indicating that people are more likely to consume alcohol on days they experience more positive rather than negative emotions (16). These unresolved contradictory results might be attributable to limitations of either methodological approach. Experimental studies may potentially overestimate the effect due to constraints that favor the hypothesis (e.g., demand characteristics (17)), while EMA studies might underestimate it due to temporal resolution limitations and contextual complexities (18,19). In this project, we aimed to test whether the tension reduction hypothesis survives a more rigorous test under controlled experimental conditions in the laboratory.

One commonality of previous lab-based investigations is that they did not require participants to actively choose alcohol over a realistic alternative following a stressor. Value-based decision-making and behavioral economic frameworks emphasize that choices depend on the *relative* subjective value of available options, not their *absolute* value (20–23). This highlights three main limitations of previous work. First, it does not provide a representation of real-world decision-making processes, where people usually have competing alternatives available. Second, the absence of meaningful alternatives means that the studies tested whether the absolute value of alcohol increases, whereas it is the value relative to alternatives that should drive decision-making. Third, it may inadvertently create conditions that make it easy for the tension reduction hypothesis to predict the data. For example, consider a study design where participants are randomly assigned to a stress or no stress condition, then placed alone in a room with alcoholic drinks available and instructions to consume as many as desired (24–26). This setup not only eliminates alternatives but may also activate participants' pre-existing beliefs about associations between stress and alcohol use (27), which could explain the increase in alcohol consumption (28). Additionally, experiencing stress could influence alcohol use through two distinct mechanisms. It could increase the likelihood of *initiating* a drinking episode, and/or it could increase the likelihood of *continuing* to drink once intoxicated, thus resulting in heavier drinking episodes.

To address these limitations, in the current study we designed and tested a novel experimental paradigm (**Figure 1**) that required participants to make explicit choices between alcoholic and non-alcoholic beverages before and after experimental manipulations. Participants first rated various drinks, then made repeated choices between alcoholic and non-alcoholic options, consumed either alcoholic (target BrAC=.06%) or non-alcoholic beverages and underwent either personalized stress induction or control procedures, then repeated the choice task. This approach tests whether stress leads participants to override their baseline preferences for non-alcoholic options, and whether this differs when people are already intoxicated versus sober.

Figure 1

This represents a higher bar for the tension reduction theory than prior studies, which have focused on any increase in alcohol consumption, because our approach requires a more substantial shift in behavior. Nonetheless, we consider this a fair test – if tension reduction is supposed to be a major motivator for alcohol use within the complexity of real-world contexts, we should observe such an effect under controlled laboratory conditions.

Finally, the introduction of an alcohol intoxication manipulation allows us to examine how the relationship between stress and the decision to consume alcohol potentially differs depending on whether the decision is about *starting* versus *continuing* to drink alcohol. In our design, we compare the effects of a stressor experienced while sober (decision to initiate) against the effects of a stressor experienced while intoxicated (decision to continue). Thus, we are not testing how a stressor experienced prior to the initiation of a drinking episode affects continued consumption. In our paradigm, differences in participants' decision to consume or not consume alcohol could be driven by different mechanisms. How carefully they are currently making decisions, their sensitivity to prior drink preferences, and their bias towards the alcoholic option regardless of preference may all play a role. If we assume that participants optimally integrate evidence for the decision over time by considering the two alternatives (29,30), we can determine the effect that stress and intoxication have on each of these mechanisms. **Error! Bookmark not defined.**This decision-making process can be formalized as a Drift Diffusion Model (DDM), a computational model that allows us to decompose choices and response times (RT) into latent decision-making mechanisms. Here, we explored whether any of these three mechanisms (decision carefulness, evidence sensitivity, alcohol bias) could explain potential stress- and intoxication-induced changes in the decision-making process. By jointly modeling choice and RT information, the DDM can reveal subtle effects of stress and intoxication that might not be apparent from the behavioral data alone.

Based on the tension reduction hypothesis, we predicted that:

H1a: Stress affects the decision between alcoholic and non-alcoholic drinks, so that participants in the stress conditions choose alcoholic over non-alcoholic drinks more often compared to participants in the no stress conditions.
H1b: Alcohol intoxication does not affect the decision between alcoholic and non-alcoholic drinks.
H1c: The effect of stress on the decision between alcohol and non-alcoholic drinks is modulated by alcohol intoxication, so that the effect of stress is stronger for participants that are intoxicated.
H2a: Stress affects the reaction time for decisions between alcoholic and non-alcoholic drinks, so that participants in the stress condition make choices between alcoholic and non-alcoholic drinks faster compared to participants in the no stress condition.
H2b: Alcohol intoxication affects the reaction time for decisions between alcoholic and non-alcoholic drinks, so that participants in the alcohol condition make choices between alcoholic and non-alcoholic drinks faster compared to participants in the no alcohol condition.

H2c: The effect of stress on the reaction time for decisions between alcohol and on-alcoholic drinks is modulated by alcohol intoxication, so that the effect of stress is stronger for participants that are intoxicated.

H3a: Stress affects at least one of three DDM parameters (drift rate, boundary, bias). We had no a priori prediction which parameter would be most affected by stress.

H3b: Alcohol intoxication affects at least one of three DDM parameters (drift rate, boundary, bias). We had no a priori prediction which parameter would be most affected by alcohol intoxication.

H3c: Stress and alcohol intoxication have an interactive effect on the DDM parameter(s) most affected by stress and alcohol. We had no a priori prediction which parameter would be most affected by the interaction.

Methods

Study design and transparency

We employed a 2×2 factorial design testing the effects of alcohol intoxication (alcohol/no alcohol) and acute stress (stress/no stress) on the decision to consume alcoholic versus non-alcoholic beverages. Those assigned to the stress conditions completed a 30-minute interview prior to the laboratory session. All participants attended an in-person laboratory session. The study procedures were reviewed and approved by the University of Washington Institutional Review Board under Study ID 00018516.

We preregistered design, hypotheses, sample size, modeling, and statistical analyses prior to data collection. Our preregistration, experimental materials, anonymized data, and analysis scripts are available on the Open Science Framework (https://osf.io/j9bkq/).

Participants

Rather than basing our power analysis on previously published effect sizes, which may be inflated due to publication bias and differ methodologically from our novel paradigm, we determined a minimum effect size of interest (η^2=.06) that would be theoretically meaningful in our field. Specifically, we conducted power simulations for a 2×2 between-subjects ANOVA using reasonable parameter values for drift rates based on our previous computational modeling work (15). These values create meaningful main effects and an interaction effect of η^2=.06, which we consider theoretically significant for understanding how stress and intoxication differentially affect decision-making processes. Our a priori power analysis indicated that data from 160 participants (40 per condition) would provide 87.76% power to detect this medium-sized interaction effect. We recruited adults from the Seattle metropolitan area via a combination of printed and online advertisements in exchange for $85-$125 based on the condition they were randomly assigned to[1]. To ensure participant safety and study validity, we established several eligibility criteria. Participants had to be 21-50 years old (legal drinking age and restricting age-related effects on RT (31)) and report regular alcohol use (≥1 drinking episode/week and ≥1 binge episode [i.e., 4/5 drinks for women/men in one occasion]/month) to ensure alcohol capacity. We excluded individuals with current/prior alcohol treatment, medical contradictions to alcohol, a lifetime history of anxiety disorder, or those who were pregnant or trying to become pregnant. These criteria minimized risk related to our experimental manipulations of intoxication and stress. If eligible and interested, participants were randomly assigned to one of four conditions.

A total of 160 individuals completed the study between February 2024 and August 2024. Participants were on average 31 years old (*SD*=7.62, *range*=21 to 50). The sample had a slightly higher proportion of males in terms of sex assigned at birth (56% male, 44% female) and gender identity (54.4% men, 39.9% women, 5.7% gender expansive). The sample included participants from various racial and ethnic backgrounds (46.2% white, 14.6% Asian, 13.3% Black/African American, 12.0% multiracial; 13.9% identified as Hispanic/Latino) and sexualities (27.9% LGBQ, 82.1% heterosexual). A minority of participants were college students (17.8%). Most participants were working either full-time (46.9%) or part-time (32.5%; 20.6% unemployed). The median Alcohol Use Disorder Identification Test score of the sample was 8 (*mean*=9.38, *SD*=4.58, *range*=2 to 22), indicating that this can be considered a high-risk drinking sample. An overview of participant characteristics split by experimental condition can be found in **Table S1**.

Randomization

Block randomization was used to randomly assign participants to one of four conditions (alcohol/stress, alcohol/no-stress, no-alcohol/stress, no-alcohol/no-stress), ensuring balanced

[1] We paid participants an additional $10 for transportation, since participants were not allowed to drive themselves to the laboratory.

group sizes of 40 participants per condition. In cases where randomized participants declined to participate (e.g., by no-showing their scheduled appointment), we assigned the next enrolled participant to the same condition as the no-show to maintain balanced allocation.

Procedures

All sessions began between 2:00pm-5:00pm. At the start of the laboratory session, participants provided informed consent and were breathalyzed to ensure that their Breath Alcohol Concentration (BrAC) at the start of the experiment was .00% (32). Participants were also asked not to consume any calories for three hours prior to the study to minimize individual differences in alcohol absorption rates. Participants assigned female sex at birth completed a pregnancy test if necessary and all participants were weighed. Participants were then seated in a cubicle and completed the first set of computer tasks (beverage rating task, 2AFC task, PVT task). Afterwards, the participants underwent the beverage administration procedure in a different room simulating a bar environment, including a wet bar, bar stools, liquor bottles, and other bar paraphernalia (**Figure S1**). They were then taken back to the cubicle and underwent the stress induction procedure and then completed another set of computer tasks. Participants in the alcohol conditions returned to a BrAC <.04% and everybody completed a set of questionnaires before being debriefed and dismissed.

Interventions

Beverage administration

All participants were seated at the bar and informed whether they would receive alcohol or not. Participants in the alcohol condition consumed vodka mixed with orange juice (1:3 ratio) in the presence of an experimenter in nine minutes to induce a target BrAC of .06%. Participants were instructed to take the entire nine minutes to slowly consume the beverage in equally sized, small sips to standardize absorption rate. We chose this moderate level of intoxication to simulate a realistic drinking scenario where participants would experience the effects of alcohol (i.e., cognitive and behavioral effects) without reaching a level of intoxication that might discourage further consumption (33). The amount of alcohol was determined by Widmark's formula:

$$BAC = \frac{A}{rW}$$

where BAC is the Blood Alcohol Concentration, A is the amount of alcohol, r is a constant volume distribution (0.68 for people who were assigned male sex at birth, 0.55 for people who were assigned female sex at birth) accounting for physiological differences, and W is the weight of the person. Participants completed rinsing procedures and subsequently were breathalyzed every four minutes until they reached the target BrAC. Participants in the no alcohol condition were informed they would receive non-alcoholic beverages and consumed water mixed with orange juice (1:3 ratio). We yoked each participant in this condition to a participant in the alcohol condition to control for procedure variables (34,35); they received the same amount of liquid (substituting water for vodka) and performed the same amount of breath tests to account for possible time effects. All participants reported their subjective intoxication (1='not at all intoxicated', 10='extremely intoxicated') prior to leaving the bar.

Personalized stress induction

In line with previous research (36–38), prior to the laboratory session, participants in the two stress conditions completed a standardized online interview with the first author. In this interview, they were asked to recall in detail a recent event they considered highly stressful. The interviewer then probed for any critical details that were left out (e.g., time and place of the event, how things looked, what was said, and which emotions, thoughts, and bodily sensations were experienced during the event). These interviews took ~30 minutes and were audio recorded so that the interviewer could create a personalized script (~500 words) describing the event[2]. Then, a research assistant recorded an audiotape from this script (~5 minutes) in a neutral tone.

First, a neutral mood was induced by displaying colors to all participants on the screen for three minutes (38,39). Then, participants in the stress condition listened to the five-minute personalized script of the stressful event described in the interview. In line with previous research (37), they were instructed to close their eyes and imagine the event described in the audiotape as vividly as possible, and to try to experience the emotions they would experience during this event as much as possible. Participants in the no stress condition got the same instructions and listened to a five-minute generic non-stressful script describing a serene scene at the beach. All participants reported their subjective level of stress (1='not at all stressed', 10='extremely stressed') and mood (1='extremely unhappy', 10='extremely happy') prior to and following the mental imaging exercise.

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[2] An anonymized example is available on the OSF.

Measures

Beverage rating task

Participants rated 60 images (30 alcoholic drinks: various beers, wines, and liquors; 30 non-alcoholic drinks: various sodas, energy drinks, and sparkling waters) on a 4-point scale (1='not at all', 2='not really', 3='a little bit', 4='a lot'). To ensure use of the full rating scale, participants were instructed to use each response option at least four times. Image presentation order was randomized, with drink type (alcoholic/non-alcoholic) block order counterbalanced across participants. These ratings provided the foundation for our personalized choice paradigm, enabling us to test whether stress could shift relative preferences between alcoholic and non-alcoholic beverages.

Two-alternative forced choice (2AFC) task

In each trial, participants chose between an alcoholic and a non-alcoholic drink they had rated earlier. Participants had four seconds to decide which drink they would rather consume in the present moment by pressing a corresponding button on the keyboard ('Z' for left and 'M' for right; drink position was randomized). While the actual beverage administration during the experiment was predetermined by condition assignment, participants were not explicitly informed about this aspect of the design. They knew only that there was a bar setting where they would receive beverages at some point during the experiment. We intentionally left this ambiguous, neither confirming nor denying whether their choices would influence what they received. This ambiguity maintained the face validity of the choice task, as participants had reasonable grounds to believe their selections might be consequential, though we never explicitly claimed this. This approach created an ecologically valid decision context without employing deception. We constructed choice pairs based on participants' ratings, creating all possible non-matching rating combinations (12 unique combinations), with 30 trials per combination (360 total trials). This ensured that alcoholic options were higher rated in exactly half the trials. Trials were separated by a 0.25s fixation cross, with an optional break after 180 trials. Participants completed this task before and after the experimental manipulations. This task measured our two primary outcomes, proportion of choices for alcohol and decision speed.

Psychomotor vigilance task (PVT)

We ran a PVT for three minutes (40). Participants were required to respond to a simple visual stimulus presented at a random interval (uniformly distributed between 2-10s) by pressing the spacebar on the keyboard as fast as possible. Participants also completed this task twice, once before and once after the experimental manipulations. These data provided non-decision time estimates for our computational modeling (see below).

Alcohol Purchase Task

In line with prior research on momentary demand (11,41), participants reported how many alcoholic drinks (min=0, max=20) they would consume after the completion of the experiment at 16 different prices ranging from $0 to $15 per drink (42). This provided complementary behavioral economic measures (intensity, O_{max}, P_{max}, breakpoint) to explore how our manipulations affected alcohol valuation.

Questionnaires

Prior to leaving the lab, participants completed a short battery of questionnaires, including the Alcohol Use Disorder Identification Test (43). Participants in the alcohol conditions completed all questionnaires only after their BrAC had decreased to below .04%, minimizing the potential influence of acute intoxication on self-report measures. Questionnaires were intentionally positioned at the end of the session to prioritize the quality and timing of our primary experimental procedures.

Analysis plan

We preregistered two sets of analyses using weakly informative priors for all main effects and interactions. We ensured models converged and fit the data well via R-hat statistics, effective sample sizes, trace plots, and posterior predictive checks.

Behavioral data

We conducted Bayesian analyses in R (44) with the brms package (45). For these analyses, we removed data from trials on which no response was made within four seconds as well as RTs under 0.3 seconds to avoid slow choices unlikely to be related to the speed of the decision-making process, and spikes in short RTs stemming from a minority of participants rapidly pressing the choice button on some trials. This resulted in the loss of 0.56% of trials. We then predicted the proportion of choices for alcohol in the post-manipulation 2AFC task from the alcohol condition, stress condition, and their interaction while controlling for the pre-manipulation choices (H1a-c). We also predicted the post-manipulation median RT while controlling for pre-manipulation median RT (H2a-c). For choices, we specified a normally distributed prior with a mean of 0 and a standard deviation of 10%, and for RTs we specified a normally distributed prior with a mean of 0 and a standard deviation of 40ms.

Drift diffusion modeling (DDM)

To understand the specific mechanisms through which stress and intoxication affect the decision-making process, we used a DDM. This type of model allowed us to distinguish whether manipulations affected how carefully participants made decisions (through changes in decision boundaries), how much their evidence accumulation process was sensitive to initial drink preferences (through changes in drift rate), or whether they developed a bias toward choosing alcohol regardless of preference (through changes in evidence accumulation bias). The DDM can be thought of as weighing options on a scale, where evidence for each choice accumulates on either side until one side tips over a threshold and triggers a decision. In our study, one side of the scale represents choosing the alcoholic option, the other choosing the non-alcoholic option. The speed and direction of evidence accumulation (how quickly and which way the scale tips) can be affected by participants' initial drink preferences and any bias toward alcohol, while the threshold for how far the scale needs to tip represents how carefully participants make their decisions. We conducted these analyses with the PyDDM library (46). We fit several DDMs to the choice and RT data from each participant's combined 2AFC trials pre- and post-manipulation.

Non-decision time estimation. The models included several adjustments and extensions to the standard DDM which were meant to improve the interpretability of the models by capturing nuanced aspects of our experimental paradigm. First, to account for individual differences in the effects of alcohol intoxication on cognitive processing, instead of treating the non-decision time as a free parameter to be estimated within the model, we assumed the non-decision time (which is of no theoretical interest to us) to be normally distributed with mean and standard deviation estimated using RTs from participant's (pre/post) PVT data. To get robust estimates, we removed PVT RTs slower than 1s and then fit a mixture model of a Gaussian distribution (representing the mean and variance for attentive responses) and a uniform distribution (representing lapses and anticipatory responses) to the PVT data:

$$RT \sim (1-p) * N(\mu, \sigma^2) + p * U(0,1)$$

This mixture model accounted for contaminant RTs in the estimation of the mean and standard deviation of the PVT RT distribution and provided more robust estimates than the sample mean and standard deviation. This approach allows us to account for individual differences in basic processing speed, ensuring that our subsequent modeling focuses specifically on decision-making processes rather than general cognitive effects of our manipulations.

Parameterization of evidence accumulation. Second, to allow the model to account for the magnitude of the subjective value difference between the alcoholic and non-alcoholic choice on each trial, we assumed that the drift rate was a scalar multiple of the difference in rating of the presented alcoholic and non-alcoholic option (ranging from -3 to 3). Third, we added a scalar bias parameter to the drift rate, representing an underlying bias in evidence accumulation for either option. We chose to model bias as a drift rate parameter rather than a starting point bias because drift rate bias reflects changes in the underlying subjective value of the options during evidence accumulation, which aligns with our theoretical framework that stress affects alcohol's relative value. In contrast, a starting point bias would represent a fixed preference independent of the options' values, which is less consistent with value-based decision-making theories. The upper boundary in our model always represented the alcoholic choice, so a positive drift rate indicated prior evidence in favor of the alcoholic choice. By incorporating subjective value differences into our drift rate calculation, we capture how participants' pre-existing preferences influence their decision process, allowing us to separate this from any manipulation-induced biases toward alcohol.

Model variants. To disentangle the effects of stress and intoxication, we hypothesized that the effects of these two manipulations would primarily impact a single parameter in the model. We allowed three model parameters, one at a time, to vary based on the manipulation: the boundary height, representing the carefulness of the decision; the drift rate, representing the rate of information integration; and the alcohol bias, representing a bias in evidence integration over time towards the alcoholic option. All other parameters were shared across the two conditions. Therefore, we focused our analysis on three models, one in which each of the three model parameters varied between pre- and post-manipulation. For comparison, we also fit a model in which all three parameters varied, and one where no parameters did. Thus, we fit a total of five preregistered models to each participant’s data. All models were governed by the dynamics of the DDM, namely,

$$dx = \mu(E, V_i)dt + dW$$

where μ is the drift rate, E is 0 if the trial is pre-manipulation and 1 if post-manipulation, V_i is the difference in value between the beverage choices on trial i, and dW is a Wiener process. The decision was terminated when

$$|x| > B(E)$$

where a positive boundary crossing indicated a choice of the alcoholic beverage, and a negative boundary crossing indicated a choice of the non-alcoholic beverage. The functions B(E) and $\mu(E, V_i)$ are defined differently for each model.

1) None of the parameters vary from pre- to post-manipulations (3 free parameters to fit):

$$\mu(E, V_i) = V_i\beta_{drift} + \beta_{bias}, B(E) = \beta_{bound}$$

2) Boundary varies from pre- to post-manipulations (4 free parameters to fit):

$$\mu(E, V_i) = V_i\beta_{drift} + \beta_{bias}, B(E) = \beta_{bound} + \beta_{\Delta bound}$$

3) Drift rate varies from pre- to post-manipulations (4 free parameters to fit):

$$\mu(E, V_i) = V_i(\beta_{drift} + E\beta_{\Delta drift}) + \beta_{bias}, B(E) = \beta_{bound}$$

4) Alcohol bias varies from pre- to post-manipulations (4 free parameters to fit):

$$\mu(E, V_i) = V_i\beta_{drift} + \beta_{bias} + E\beta_{\Delta bias}, B(E) = \beta_{bound}$$

5) All three parameters vary from pre- to post-manipulations (6 parameters to fit):

$$\mu(E, V_i) = V_i(\beta_{drift} + E\beta_{\Delta drift}) + \beta_{bias} + E\beta_{\Delta bias}, B(E) = \beta_{bound} + \beta_{\Delta bound}$$

The final model RT distribution was computed by adding the distribution of termination times, the 'decision time', to a normal distribution with parameters derived from the PVT data, the 'non-decision time'. The model was fit using maximum likelihood on the full RT distribution. We extracted and predicted the change in the parameters of interest from pre- to post-manipulations, which were directly estimated by fitting the models simultaneously to both pre- and post-manipulation trials (H3a-c). The model variants allow us to systematically test whether stress and intoxication primarily affect decision carefulness (boundary parameter), value sensitivity (drift rate parameter), or create a bias toward alcohol regardless of preference (bias parameter). This systematic approach enables us to pinpoint the specific cognitive mechanisms affected by our manipulations.

Inference criteria

We report the full posterior distribution for each parameter of interest. For the behavioral data, we preregistered a decision rule that we consider the null hypothesis rejected if the 95% highest density interval (HDI) falls completely outside a specified region of practical equivalence (ROPE), consider the null hypothesis supported if the 95% HDI falls completely within the ROPE, and determine the results as ambiguous if the 95% HDI falls neither completely within nor outside the ROPE (47). We specified this ROPE as a difference of ±5% of choices for alcoholic drinks and ± 0.2 seconds in median RT. For the DDM parameters, as we had no a priori expectations which effect sizes are meaningful, we preregistered to interpret any 95% HDI excluding 0 as evidence in favor of our hypotheses.

Sensitivity and exploratory analyses

We preregistered two sensitivity analyses as we anticipated two potential limitations of our stress induction procedure. First, we anticipated that there might be a subset of participants who do not report an increase in stress in the stress conditions/report an in- or decrease in stress in the no stress conditions. For that reason, we repeated our analyses excluding these participants (N = 132[3]). Second, we considered it a possibility that the strength of the stress induction wanes over the time it takes to complete the 2AFC task. For that reason, we repeated our analyses focusing on the first half of 2AFC trials (N = 160). We conducted a third, non-preregistered sensitivity analysis in which we excluded participants who responded to more than 10% of the 2AFC trials faster than their own mean RT in the PVT (N = 151). This exclusion criterion was designed to identify participants who may not have taken the 2AFC task seriously. For exploratory purposes, we predicted behavioral economic demand indices (intensity, breakpoint, O_{max}, P_{max}) derived from the APT data with the beezdemand package (48).

Results

Figure S2 visualizes the CONSORT flow diagram for this study. 1153 individuals were screened for eligibility, of which 919 did not meet inclusion criteria and were excluded. A total of 234 individuals were initially randomized to one of the four experimental conditions. However, 74 randomized participants declined to participate or did not show up for their scheduled laboratory session. Following our pre-established protocol for maintaining balanced

[3] Removed participants in sensitivity analyses did not differ from non-removed participants in terms of key participant characteristics.

groups across conditions, these participants were replaced by assigning the next enrolled participant to the same condition as the no-show. This approach was necessary because personalized scripts needed to be prepared in advance of the laboratory sessions. Ultimately, 160 participants (40 per condition: no alcohol/no stress, no alcohol/stress, alcohol/no stress, and alcohol/stress) completed the study and were included in the analyses.

Manipulation checks

Alcohol intoxication

Following the beverage administration, participants in the alcohol conditions on average reported higher intoxication (M=4.96, SD=1.85, *range*=1 to 9; *Cohen's d*=2.93) compared to participants in the no alcohol conditions (M=1.06, SD=0.33, *range*=1 to 3; **Figure 2a**). While self-reported intoxication in the alcohol conditions was moderate on average, the wide range of subjective responses observed suggests that individuals experienced the same BrAC quite differently, highlighting the variability in alcohol's perceived effects across participants.

Stress

Following the stress induction, participants in the stress conditions on average reported a greater increase in stress (M=3.46, SD=1.98, range=0 to 7; *Cohen's d*=2.40; **Figure 2b**) and greater decrease in mood (M=-1.94, SD=1.77, *range* =-6 to 4; *Cohen's d*=1.55; **Figure 2c**) compared to participants in the no stress conditions ($M_{\Delta Stress}$=-0.24, SD=0.92, *range*=-4 to 2; $M_{\Delta Mood}$=0.49, SD=1.31, *range*=-4 to 7).

Figure 2

Preregistered analyses

Behavioral data

We first established that participants used the full range of the rating scale and showed no systematic biases in their baseline preferences. In the beverage rating task, participants chose each response option roughly equally often (Alcohol: 'Not at all'=25.13%, 'Not really'=24.72%, 'A little bit'=27.97%, 'A lot'=22.19%; No alcohol: 'Not at all'=26.17%, 'Not really'=22.82%, 'A little bit'=26.21%, 'A lot'=24.80%). Across all 2AFC trials, participants chose the alcohol option 51.24% of the time. The median 2AFC RT was 0.936s.

We then analyzed the proportion of choices for alcohol in the post-manipulation 2AFC task while controlling for pre-manipulation choices. The 95% HDI for the effect of stress (0.01, 0.13) fell only partially outside of the ROPE ±5% of choices for alcoholic drinks. Most of the posterior distribution lay outside of the ROPE, with a 76.6% posterior probability that the effect of stress exceeds 5% more choices for alcohol, indicating moderate (but not unambiguous) support for an effect of stress. The effect of alcohol (-0.06, 0.05) fell within the ROPE, indicating clear support for the null hypothesis that people are no more/less likely to choose alcohol at a BAC of .06%. The 95% HDI for the interaction (-0.15, 0.00) partially fell outside the ROPE, indicating an inconclusive result and suggesting a possible interaction where the effect of stress might be stronger when people are not intoxicated (**Figure 3a-b**).

We conducted three sensitivity analyses to address potential limitations in our study. The first analysis, excluding participants who did not report increased stress in the two stress conditions, showed a stronger effect of stress on choices for alcohol, with the 95% HDI falling outside the ROPE (0.05, 0.16). The second and third analyses, examining the first half of 2AFC trials (95% HDI=[0.02, 0.14]) and excluding potentially non-attentive participants (95% HDI=[0.01, 0.13]) respectively, yielded results consistent with our primary analysis. These sensitivity analyses generally support the robustness of our main findings, with the exclusion of stress non-responders providing stronger evidence for the effect of stress on choices in favor of alcohol.

Second, we analyzed the median RT in the post-manipulation 2AFC task while controlling for the median RT pre-manipulation. All 95% HDIs fell inside our preregistered ROPE of ± 0.20s (stress: [-0.007, 0.006], alcohol: [-0.002, 0.011], interaction: [-0.012, 0.006]) providing unambiguous support for the null hypotheses that neither manipulation affects RTs (**Figure 3c-d**). These effects remained consistent in our three sensitivity analyses.

Figure 3

Drift diffusion modeling

We fit a series of DDMs to the 2AFC choice and RT data to explore three potential mechanisms that could explain the observed effects of stress and intoxication on drink choices: changes in the decision carefulness (boundary), changes in the sensitivity to evidence (drift rate), or changes in the bias of evidence accumulation towards alcohol (alcohol bias). While our analyses of RTs showed no overall differences between conditions, the DDM can detect subtle effects with greater statistical power by jointly modeling how choices and RTs vary across different trial types. For instance, an increase in decision boundary would lead to both slower responses on easy choices (where the preferred option is clear) and more accurate responses on difficult choices (where options are similarly valued) - a trade-off that might not be apparent when looking at average RTs alone. First, we confirmed that the models show qualitatively good fits to the data (**Figure S3**).

The effect of the DDM parameters on the psychometric and chronometric functions are shown in **Figure 4**. Larger decision boundaries lead to choices that more consistently follow value differences but produce slower responses overall, reflecting more careful but time-consuming decision-making. Higher drift rates produce steeper choice curves and faster responses, indicating increased sensitivity to value differences. A bias towards alcohol shifts the choice curve leftward, such that a 50% probability of choosing alcohol occurs even when there is a slight baseline preference for non-alcoholic options. Similarly, RTs peak when there is a slight preference for non-alcoholic options, suggesting greatest response conflict when the bias towards alcohol counteracts a mild preference for non-alcoholic beverages. At the population level, we confirm a strong correlation between the predicted and observed mean RT (r=.98), and the manipulation's effect parameters derived from the models where only one parameter varies with those of the full model ($r_{boundary}$=.95; r_{drift}=.76; r_{bias}=.98).

Figure 4

The results indicated clear support for changes in alcohol bias as the primary mechanism underlying the observed effect of stress on drink choices (95% HDI [0.19, 0.76]), while showing no evidence for changes in decision carefulness (95% $HDI_{boundary}$ [-0.13, 0.07]) or the rate of evidence accumulation (95% HDI_{drift} [-0.09, 0.09]) due to stress. Intoxication did not systematically affect any parameter (95% $HDI_{boundary}$ [-0.07, 0.13]; 95% HDI_{drift} [-0.16, 0.02]; 95% HDI_{bias} [-0.31, 0.28]), while there was some evidence for an interaction between stress and intoxication suggesting the bias parameter, but not the boundary or drift rate, was more affected for participants who were stressed and sober (95% $HDI_{boundary}$ [-0.19, 0.09], 95% HDI_{drift} [-0.10, 0.16], 95% HDI_{bias} [-0.81, -0.01]; **Figure 5**). All results remained consistent in the three sensitivity analyses. The consistency of alcohol bias from pre- to post-manipulation varied across conditions. In the no alcohol and no stress condition, only 10% of participants showed a reversal in their bias direction. By contrast, in the alcohol and stress condition, 35% showed a change in bias direction (20% in no alcohol and stress condition, 27.5% in alcohol and no stress condition), suggesting that stress and intoxication might have led to more variable changes in participants' bias towards or away from the alcoholic option.

Figure 5

Our above analyses assume that only one parameter varied between the pre- and post-conditions. However, we found that, consistent across all conditions, boundary decreased, and drift rate increased from pre- to post-manipulation. Therefore, we wanted to understand whether this difference, which could not be accounted for by the model which only allows alcohol bias to vary, was influencing our results on the alcohol bias. Furthermore, we wanted to know whether this difference was mechanistically a change in carefulness (i.e., participants were less likely to prioritize high performance on the task), or due to an increased sensitivity to evidence, which could be due to their increased familiarity with the stimuli. Therefore, we analyzed the parameters from the full model, in which all three variables could change between pre- and post-manipulation. Specifically, we wanted to know whether the alcohol bias effect still held, and whether there were differences in only one drift rate and boundary, or in both. The results from the full model were consistent with the results from the individual models, with stress affecting the bias parameter (95% HDI [0.22, 0.69] but not the boundary (95% HID [-0.13, 0.07]) or drift rate (95% HDI [-0.09, 0.05]). There was some evidence that, for participants who were sober, stress had a stronger effect on the bias parameter (95% $HDI_{interaction}$ [-0.68, -0.01]), but not the boundary (95% $HDI_{interaction}$ [-0.19, 0.09]) or drift rate (95% $HDI_{interaction}$ [-0.09, 0.05]) parameters.

Additionally, we wanted to understand whether the bias, which had the biggest effect across experimental conditions, also explained most of the changes in the RT distribution. To do this, we looked at the improvement in model fit from each of these three factors. We normalized the log likelihood using the baseline model and the full model and compared this normalized improvement across the three models. If all the improvement in model fit between the baseline and full model is due to a single parameter, then the model which allows only this single parameter to change will perform just as well as the full model. Our results show that, while all model mechanisms could explain some differences from pre- to post-manipulation, the largest improvement came from the boundary parameter, not the bias (**Figure 6**). Therefore, while the largest differences were due to differences in subjects' decision carefulness, these changes tended to favor faster, less accurate responses for all conditions and were unrelated to stress or alcohol consumption. This explains one reason why the DDM was able to identify the change in bias, which was invisible in the raw behavioral responses.

Figure 6

Understanding preference reversals

To further understand the practical significance of stress-induced changes in choice behavior, we descriptively examined how stress affected preference reversals: instances where participants chose alcoholic beverages despite having rated the non-alcoholic alternative higher. In the no alcohol/no stress condition, participants chose lower-rated alcoholic options in 55.9% of applicable trials. When stressed (no alcohol/stress condition), this increased to 61.3%, a 5.4% increase that was consistent across preference magnitudes, including one-point differences (54.8% to 60.7%), two-point differences (54.1% to 58.9%), and three-point differences (56.1% to 61.5%). Notably, this pattern was reversed in intoxicated participants, with fewer preference reversals in the alcohol/stress condition (52.7%) compared to alcohol/no stress (55.7%). These findings complement our computational modeling results, demonstrating that stress not only biases internal evidence accumulation toward alcohol but can lead sober participants to override their baseline preferences, choosing alcohol despite initially rating non-alcoholic alternatives higher.

Demographic considerations

While our block randomization was designed to ensure balanced group sizes, we observed an imbalance in sex distribution across conditions, with stress conditions having higher proportions of female participants compared to no-stress conditions. This imbalance might have resulted from random chance or from our replacement protocol for no-show participants combined with potential differential dropout patterns, as randomization had to occur prior to laboratory sessions due to the need to prepare personalized stress induction materials. However, this imbalance does not affect our conclusions, as the stress induction was equally effective for female ($M_{\Delta Stress}$=3.47) and male ($M_{\Delta Stress}$=3.45) participants, controlling for sex in our models did not alter the pattern of results, and there was no evidence for sex moderation of our key findings (see supplementary materials for detailed analyses).

Alcohol purchase task

The APT assessed participants' willingness to consume alcohol at varying price points following the experimental manipulations. **Figure 7** shows demand curves from the APT data across conditions. While the alcohol and stress group showed lower average demand for alcohol when alcohol is free (i.e., intensity; *M*=3.68) compared to the no alcohol/no stress (*M*=5.53), no alcohol/stress (*M*=4.70), and alcohol/no stress (*M*=5.00) groups, substantial within-group variability resulted in wide credible intervals for all effects (95% HDI_{stress}=[-2.15, 0.45], 95% $HDI_{alcohol}$=[-1.83, 0.80], 95% $HDI_{interaction}$=[-2.28, 1.38]). This uncertainty in the APT data makes it difficult to draw firm conclusions about differences in absolute alcohol valuation. There was no effect on breakpoint, O_{max}, or P_{max}.

Figure 7

Discussion

In this study, we set out to provide a stringent test of the tension reduction hypothesis (4) under controlled laboratory conditions. Using a decision-making paradigm, in which the hypothesis could only be supported if acute stress causes participants to start choosing alcohol over a more appealing non-alcoholic alternative, we found nuanced support for the hypothesis while highlighting important boundary conditions.

Our behavioral findings provide novel evidence for the tension reduction hypothesis. We found that acute stress moderately increased sober participants' propensity to choose alcoholic over non-alcoholic beverages. This finding goes beyond previous studies (8,9,13) by demonstrating that stress motivated participants to occasionally overcome their baseline preference for non-alcoholic options. By design, half our trials paired alcoholic drinks with higher-rated non-alcoholic options, so any increase in alcohol choices above 50% required participants to sometimes choose alcohol despite having rated it lower than the alternative (e.g., choosing an alcoholic drink rated 2-'not really' over a non-alcoholic drink rated 3-'a little bit').

While the effect size was modest, paired with the computational evidence from the DDM this represents particularly compelling evidence for tension reduction under a value-based decision-making framework (20,21) - stress had to shift the relative value of alcohol enough to overcome an existing preference for the alternative. Previous studies often measured absolute alcohol consumption or craving without requiring participants to actively choose alcohol over a realistic, appealing alternative. By demonstrating that stress can reverse preferences in favor of alcohol, our findings suggest stress may genuinely increase alcohol's relative value rather than simply activating automatic response tendencies under controlled laboratory conditions.

Our computational model revealed that stress primarily affected decision-making by inducing a bias toward alcohol during the evidence accumulation process, without affecting how carefully decisions were made or participants' overall evidence sensitivity. This strengthening of evidence accumulation towards the decision boundary reflecting alcohol was more pronounced than the observed changes in choice behavior, suggesting that while stress consistently biases the evaluation process toward alcohol, this bias only sometimes is strong enough to overcome reasons not to choose alcohol (in this case, the baseline preference for the non-alcoholic option). In other words, even when stressed, participants appear to weigh competing considerations rather than automatically choosing alcohol, with stress increasing but not guaranteeing choices for alcohol. While previous research established that stress could increase alcohol consumption and craving, our computational model provides new mechanistic insight into how stress dynamically influences the decision process itself, showing that it specifically biases ongoing value computation rather than affecting more general aspects of decision-making like decision carefulness or sensitivity to differences between drinks.

These effects only appeared in sober participants, indicating (in the context of our experimental paradigm) that stress may primarily influence how alcohol's relative value is processed during initial drinking decisions rather than decisions about continued consumption. This may suggest an important boundary condition for the tension reduction hypothesis. While our study was not designed to determine the physiological or psychological mechanisms underlying this boundary condition, several speculative explanations warrant consideration. First, alcohol and stress may operate through overlapping psychological processes to increase alcohol's perceived relative value (49) - once a person is intoxicated, stress cannot provide additional motivation through these same mechanisms, representing a ceiling effect on value computation. Second, while the stress induction appeared equally effective in sober and intoxicated participants, alcohol may have disrupted the ability of intoxicated participants to incorporate this affective state into their decision process. Our DDM results showed that in sober participants, stress specifically affected the rate of evidence accumulation favoring alcohol choices. Alcohol may impair this precise computational mechanism (50,51) - the integration of current emotional states into value-based decision making. These speculative accounts make distinct predictions: if driven by a ceiling effect on value, the stress effect should re-emerge at lower levels of intoxication, whereas if driven by computational disruption, similar boundary conditions should emerge for other manipulations intended to bias choice. Future studies systematically varying blood alcohol levels and testing different types of choice-biasing manipulations (e.g., the social context of the decision (52,53)) could help distinguish between these possibilities.

Our findings offer one potential explanation for the divergent results between prior laboratory and ecologically valid studies (16). In controlled settings, we minimize opportunity costs (54,55) and competing factors that typically constrain alcohol consumption, potentially allowing this bias mechanism to manifest more clearly in behavior. In contrast, in daily life, numerous practical barriers and additional alternatives might interact with any stress-induced bias toward alcohol. Additionally, the day-level temporal resolution of most EMA studies may obscure more granular effects where stress temporarily increases alcohol's relative value (18,19). A recent EMA study indicated that stress responses to a stressful event only last about 15 minutes in daily life (56). However, this proposed explanation requires direct empirical investigation - future studies combining fine-grained temporal measurement with explicit assessment of real-world constraints could help determine whether this mechanism explains the disconnect between laboratory and ecological findings.

This study, while providing novel mechanistic insights, has important limitations. Our simplified laboratory paradigm, while necessary for isolating decision mechanisms, abstracts away many real-world complexities. Participants made choices without the typical constraints of daily responsibilities or social influences that often regulate drinking behavior (57–59). Additionally, we examined only one type of acute psychological stress, while tension reduction and affect regulation theories often conceptualize various negative emotional states (e.g., stress, anxiety, sadness, anger) as equivalent triggers for alcohol use. This broad grouping of distinct emotional states may obscure important mechanistic differences in how they influence alcohol-related decision making (60). We also did not sample many participants with severe AUD, and we excluded individuals with current or past anxiety disorders. Thus, while our findings advance our understanding of tension reduction in a broader at-risk population, they may not generalize to individuals with severe AUD and comorbid conditions, where the relationship between stress and alcohol choice behavior could be more pronounced (61). We did not screen for or exclude participants based on other substance use disorders, nor did we assess concurrent substance use on testing days, which could have introduced additional variance in participants' cognitive processing, stress reactivity, or response to alcohol. Future studies might benefit from screening for recent substance use to reduce potential sources of individual variability in experimental responses.

These limitations suggest several promising directions for future research. Laboratory studies could systematically increase ecological validity by introducing subsequent responsibilities (e.g., simulated work tasks) or manipulating social context during the decision process (52–54). Different types of negative emotional states could be systematically compared to develop more nuanced theoretical frameworks distinguishing their effects on alcohol choice. Additionally, the boundary condition we identified - that stress effects appear primarily when sober - warrants investigation across different blood alcohol levels to better understand the dose-response relationship (62). The bias mechanism identified here could also be investigated in naturalistic settings. EMA studies incorporating momentary choice paradigms could test whether stress increases preference for alcohol specifically when people are sober and practical barriers are minimal. Such studies could also examine how various real-world factors (time of day, day of week, social context, next-day responsibilities) moderate any stress-induced bias. This would help clarify whether the laboratory-identified mechanism generalizes to everyday decision-making and under what conditions it manifests in actual drinking behavior. While our study directly compares how stress affects alcohol choice in both sober and intoxicated states, we do not test how stress experienced prior to initiating drinking might influence subsequent decisions to continue drinking once intoxicated. Future research could explore these more complex temporal relationships, for example by inducing stress before initial consumption and then measuring how this affects both initial drinking and subsequent decisions to continue drinking after intoxication has been established. Such work would complement our findings by examining whether the stress-alcohol relationship depends on the timing of stress relative to the drinking episode.

In conclusion, this investigation advances our understanding of how stress influences alcohol-related decision making. We found that stress induces a computational bias toward alcohol that manifests behaviorally primarily when people are sober. These findings suggest interventions might focus on strengthening competing motivations during high-stress moments (23,63), particularly during decisions about initiating rather than continuing drinking episodes.

Data availability statement: Processed de-identified participant data and analysis scripts are available at https://osf.io/j9bkq/.

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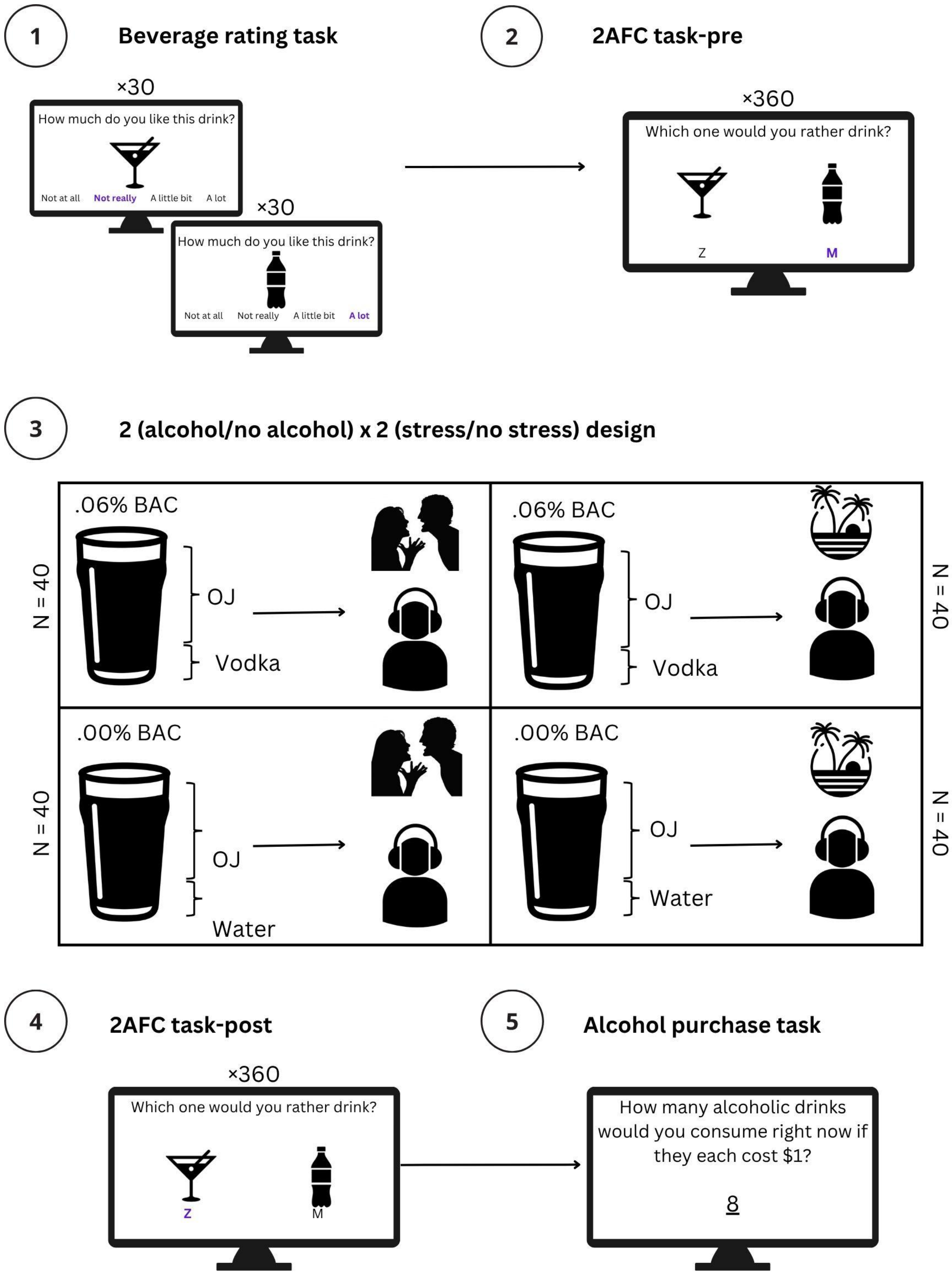
1
Beverage rating task
×30
How much do you like this drink?
Not at all
Not really
A little bit
A lot
×30
How much do you like this drink?
Not at all
Not really
A little bit
A lot
2
2AFC task-pre
×360
Which one would you rather drink?
Z
M
3
2 (alcohol/no alcohol) x 2 (stress/no stress) design
.06% BAC
OJ
Vodka
N = 40
.06% BAC
OJ
Vodka
N = 40
.00% BAC
OJ
Water
N = 40
.00% BAC
OJ
Water
N = 40
4
2AFC task-post
×360
Which one would you rather drink?
Z
M
5
Alcohol purchase task
How many alcoholic drinks would you consume right now if they each cost $1?
8

Figure 1. Experimental procedure and timeline. (1) **Beverage rating task**: Participants rated 60 drink images (30 alcoholic, 30 non-alcoholic) on a 4-point preference scale. (2) **Pre-manipulation choice task (2AFC)**: Using individual ratings, participants made 360 binary choices between personalized alcoholic and non-alcoholic drink pairs, with alcoholic options rated higher in exactly half the trials. (3) **Experimental manipulations**: Participants were randomly assigned to a 2×2 design - consuming either alcoholic beverages (target BrAC=.06%) or non-alcoholic beverages in a simulated bar, followed by either personalized stress induction (recording of their own stressful memory) or neutral control. (4) **Post-manipulation choice task**: Participants completed another 360 choices to assess how manipulations affected alcohol preferences. (5) **Alcohol Purchase Task**: Participants reported drink purchasing intentions at various prices.

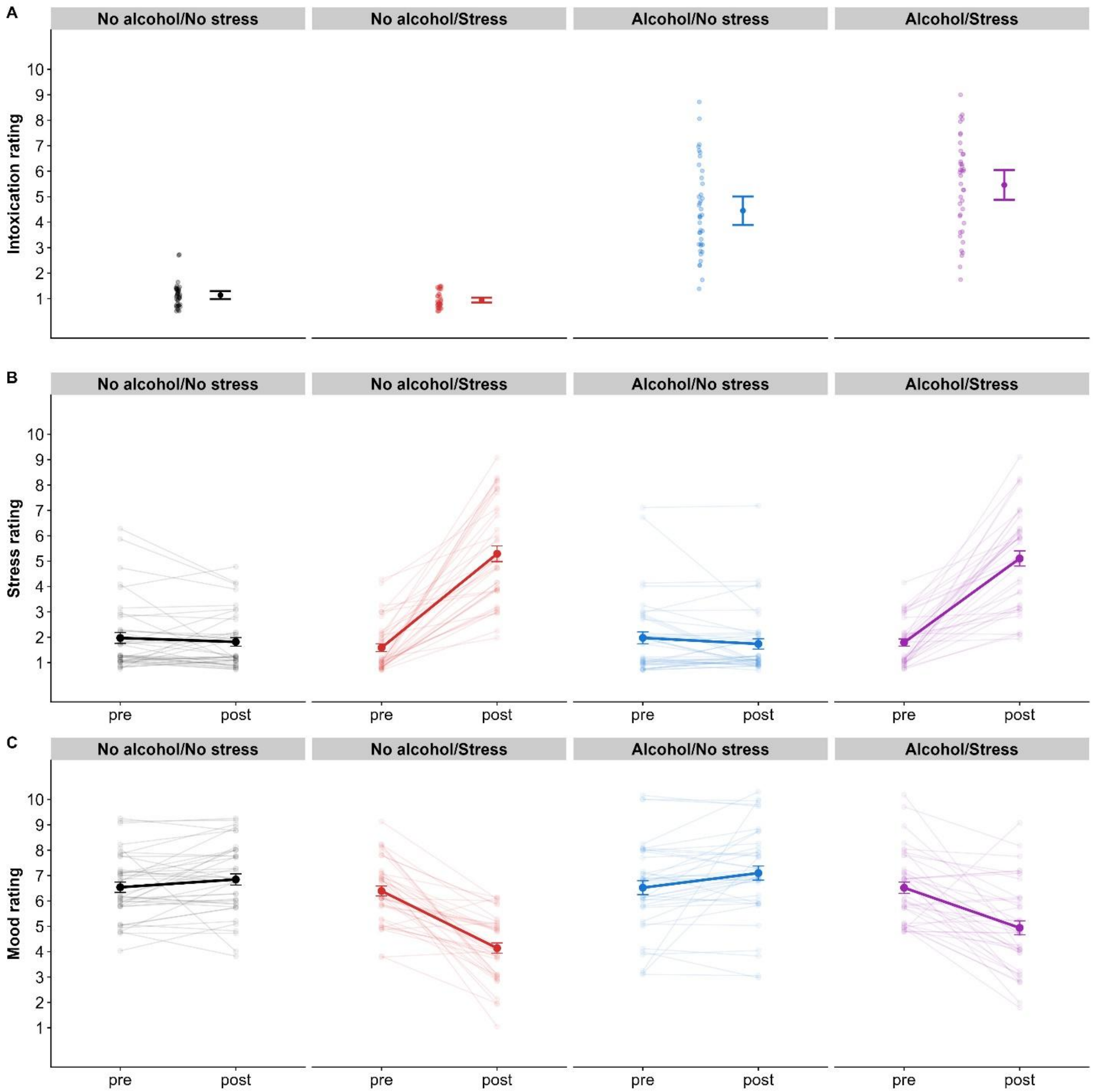

Figure 2. Manipulation checks. (a) Self-reported intoxication after the beverage administration. (b) Change in self-reported stress after the stress induction. (c) Change in self-reported mood after the stress induction. Thick lines represent group averages; individual data points show responses from each participant within each experimental condition.

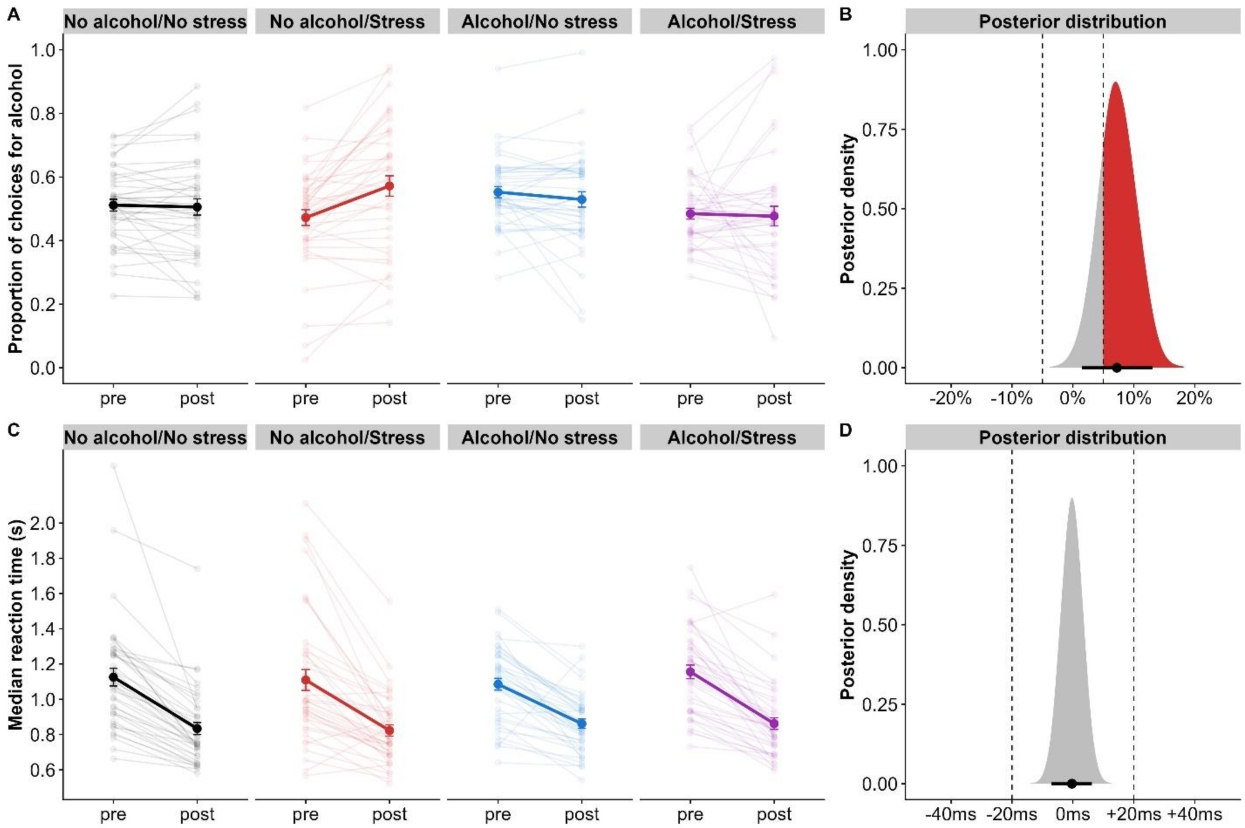

Figure 3. Choice and RT data. (a) Proportion of choices for alcohol pre- and post-manipulation. (b) Posterior distribution for the effect of stress on choices in the main analysis. (c) Median RTs pre- and post-manipulation. (d) Posterior distribution for the effect of stress on median RT in the main analysis. Thick lines represent group averages; individual data points show responses from each participant within each experimental condition.

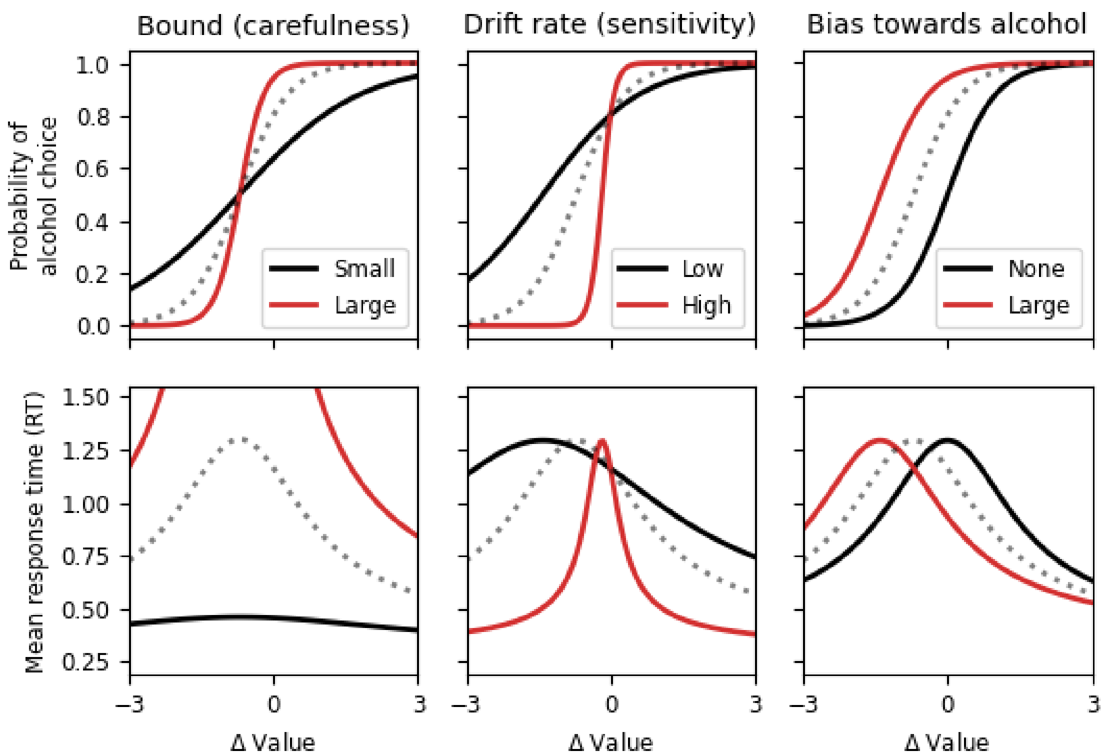

Figure 4. Schematic showing the effect of DDM parameters on psychometric and chronometric functions. Predicted effects of decision carefulness (left), drift rate (middle), and alcohol bias (right) on choice probability (top) and RT (bottom) as a function of value differences between alcoholic and non-alcoholic options (ΔValue). Solid black lines represent simulated small/low parameter values, dotted black lines represent intermediate parameter values, and solid red lines represent large/high parameter values for each mechanism being varied.

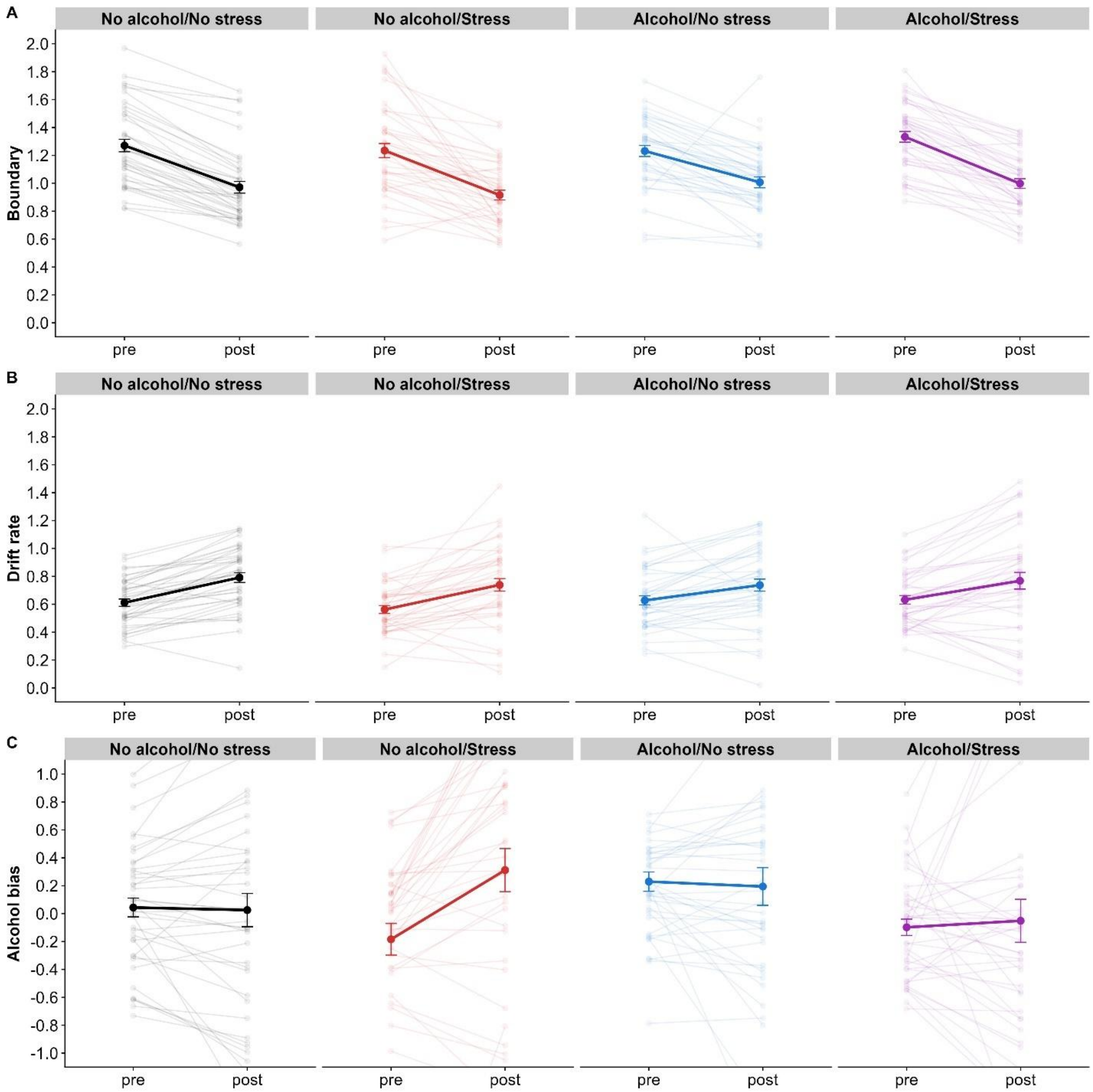

Figure 5. DDM parameters. (a) Change in boundary from pre- to post-manipulation. (b) Change in drift rate from pre- to post-manipulation. (c) Change in alcohol bias from pre- to post-manipulation. Thick lines represent group averages; individual data points show responses from each participant within each experimental condition.

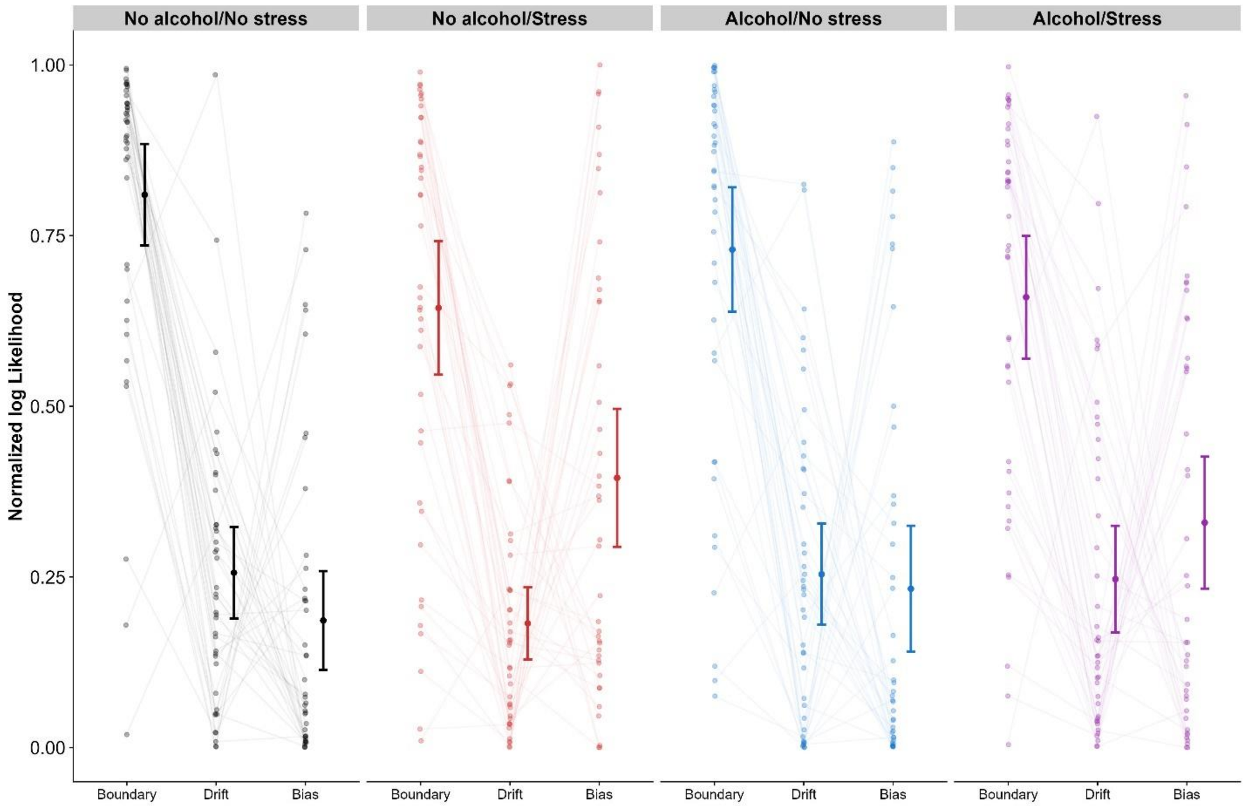

Figure 6. Improvement in log likelihood for each model. Improvement in model fit (normalized log likelihood) when allowing each parameter to vary between pre- and post-manipulation. Higher values indicate that changes in the parameter explain more of the differences between pre- and post-manipulation performance. While the bias parameter showed the largest experimental effects, changes in decision boundary explained the greatest overall variance in behavior across all conditions.

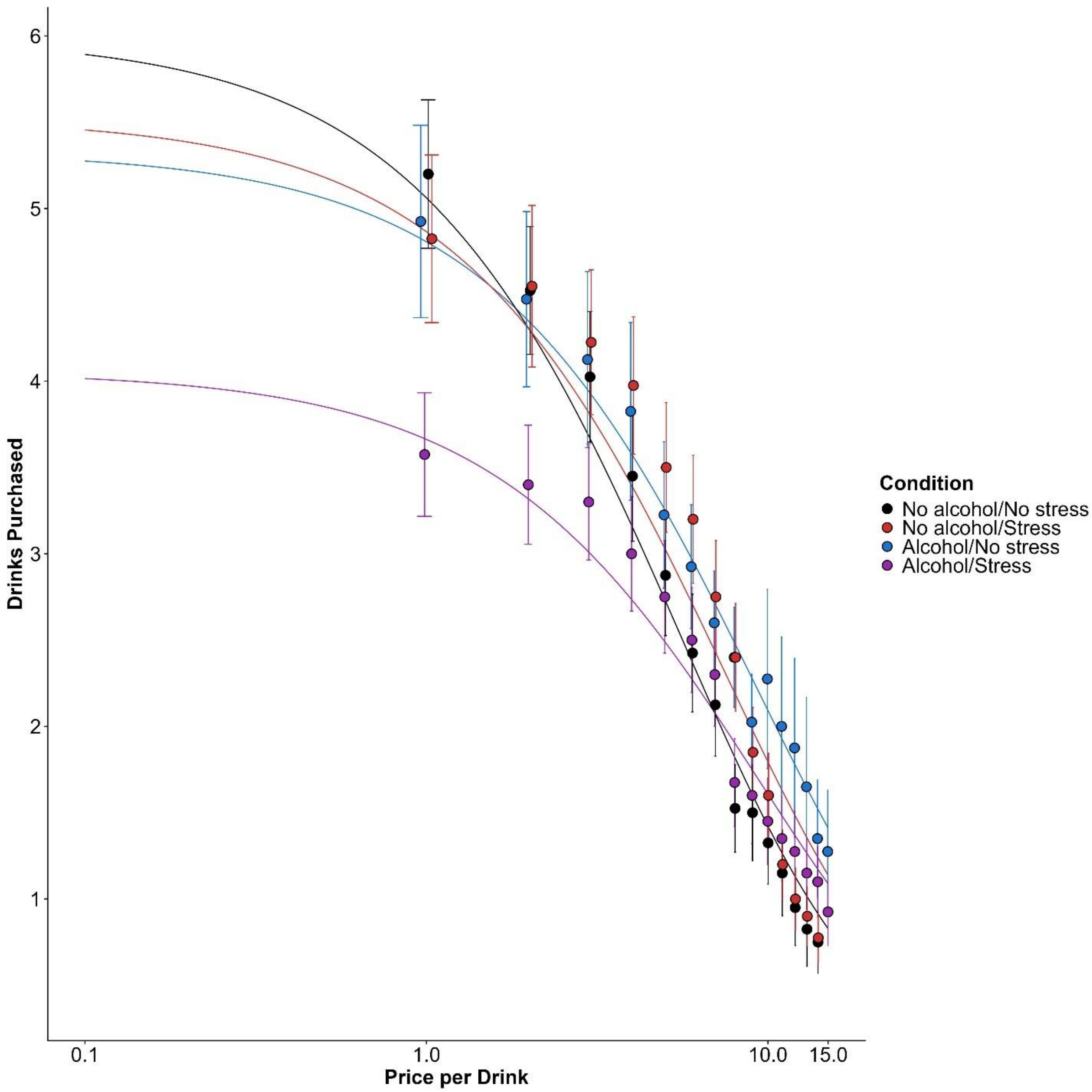

Figure 7. APT data. Behavioral economic demand curves showing the number of alcoholic drinks participants would consume at different price points following the experimental manipulations. Each line represents the average demand for one of the four experimental conditions (alcohol/stress, alcohol/no-stress, no-alcohol/stress, no-alcohol/no-stress). Higher curves indicate greater willingness to consume alcohol at each price point. Shaded areas represent confidence intervals around each group mean.