Preliminary support for the role of alcohol cues in food cravings and attentional biases

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Abstract

This study examined whether alcohol odors, in isolation or when combined with pictures (food vs. alcohol), would influence food attentional biases and cravings. Participants' cravings and attentional biases to food and alcohol pictures were assessed after exposure to alcohol or water odors (*n* = 77; mean age = 30.84, 51.9% female, 83.1% Caucasian). Food attentional biases were increased by alcohol odors, but food cravings were increased only by a combination of alcohol odors and food pictures. These effects were related with self-reported problematic food consumption. These preliminary findings support a research program for further examining the effect of alcohol cues on problematic food consumption.

Keywords: alcohol; food; cravings; attentional biases.

Introduction

Problematic food consumption and problematic alcohol consumption are often comorbid (Braun et al., 1994; Dunn et al., 2002; Grilo et al., 1989; Stewart et al., 2006; Taylor et al., 1993). This comorbidity can result in greater physical health problems and higher mortality risk (Dunn et al., 2002; Hingson et al., 2005; Hudson et al., 2007; Stewart et al., 2006). Considering the harmful consequences associated with such a comorbidity (Hudson et al., 2007; Stewart et al., 2006), a better understanding of food and alcohol co-consumption could inform effective treatment and prevention approaches (Sinha & O'Malley, 2000).

The relationship between problematic food and alcohol consumption is not well understood. Prior studies have posited that alcohol has a disinhibiting effect on food consumption (see Karyadi et al., 2013). In support of this, multiple studies have demonstrated that alcohol consumption causes individuals to consume larger amounts of food (Caton et al., 2004; Caton et al., 2005; Caton et al., 2007; Hetherington et al., 2001; Yeomans, 2010; Yeomans et al., 1999). However, not all studies have fully supported alcohol's disinhibiting effect (Christiansen et al., 2016; Ouwens et al., 2003). Additionally, the relationship between body mass index and alcohol consumption is inconsistent (Barboriak et al., 1978; Colditz et al., 1991; Gearhardt & Corbin, 2009; Kleiner et al., 2004; Lahti-Koski et al., 2002; Rohrer et al., 2005; Windham et al., 1983), which further suggests that alcohol consumption does not always disinhibit food consumption.

Importantly, previous laboratory work gave participants alcohol to consume prior to measuring the resulting amount of food consumption (Caton et al., 2004; Caton et al., 2005; Caton et al., 2007). Such a study design confounds the effect of alcohol consumption on food consumption because participants were exposed to alcohol cues (i.e., sight, taste, and smell of alcohol) in addition to consuming alcohol. In this way, the increased amount of food consumed in those prior studies could be driven by the pharmacological effect of alcohol, the effect of alcohol cues, or a combination of the two effects (see Karyadi et al., 2013). Unfortunately, no studies have examined whether alcohol cues could influence food consumption independent of alcohol's pharmacological effect.

The current study aimed to examine whether alcohol odors, in isolation or when combined with food or alcohol pictures, would influence food cravings and attentional biases. Of note, food attentional biases refer to the tendency to attend to specific stimuli in the environment, such as the sight of food (Castellanos et al., 2009; Dobson & Dozoiz, 2004; Townshend & Duka, 2001; Yokum et al., 2011). Food cravings refer to subjective states that motivate consumption (Wardle, 1990). We chose food cravings and attentional biases because they have been previously linked to increased food consumption (Jansen, 1998; Laibson, 2001; Shafran et al., 2007; Smeets et al., 2008). Moreover, the role of alcohol cues in food attentional biases, cravings, and consumption has been supported by multiple classical conditioning models (Castellanos et al., 2009; Powley, 1977; Siegel, 1983; Wardle, 1990).

Considering that food cravings and attentional biases have been linked to increased food consumption (Jansen, 1998; Shafran et al., 2007; Smeets et al., 2008; Wardle, 1990), the present study is an important first step in a program of research to further clarify how alcohol consumption leads to increased food consumption. We hypothesized that alcohol odors, in isolation or when combined with pictures, would increase both food attentional biases and cravings. In exploratory analyses, we examined the association of these food cravings and attentional biases with self-reported problematic food consumption. As a manipulation check, we examined the effect of odors and/or pictures on alcohol cravings and attentional biases.

Methods

Participants

Participants were recruited via public advertisements, which indicated that participants must provide their phone number for a phone interview to assess eligibility and would receive $20 for participating in the study. Participants who (1) consume beer at least once a week, (2) enjoy co-consuming beer and pizza, (3) are fluent in English, and (4) are at least 18 years old were recruited. These inclusion criteria ensured that participants have a history of co-consumption in order to maximize power to detect an effect should one exist. Study procedures have been approved by the university's Institutional Review Board. All participants gave informed consent to participate in the study.

Measures and materials

Cravings. Cravings were measured using the Alcohol Urge Questionnaire (AUQ; Bohn et al., 1995) and the Food Cravings Questionnaire-State (FCQ-S; Cepeda-Benito et al., 2001). The AUQ and the FCQ-S were calculated as a summed value and a mean value, respectively, with higher values indicating higher cravings. Cravings were measured once at baseline and after each trial. Internal consistency coefficients were comparable across baseline and all trials for alcohol (α's = 0.86 to 0.93) and food cravings (α's = 0.92 to 0.95). Of note, food cravings can be considered one of two primary outcome variables in the present study, while alcohol cravings were included only as a manipulation check.

Attentional biases. Attentional biases were measured using the visual probe task and an eye-tracking device (Castellanos et al., 2009; Field & Eastwood, 2005). We examined the effect of alcohol odors on both food attentional biases and alcohol attentional biases, with the latter analysis being included as a manipulation check. Three forms of attentional biases were assessed.

First, using the visual probe task, participants were presented with alcohol pictures (alcohol visual probe task) or food pictures (food visual probe task) paired with matched control pictures side-by-side, with each presentation lasting 1 second; afterward, they saw a visual probe (right or left arrow). They were instructed to press the left and right mouse button when they see a left and right arrow, respectively. Faster average reaction time (in milliseconds) toward probes replacing food or alcohol pictures versus matched control pictures is indicative of greater *cognitive attentional biases.* Second, eye-tracking measured visual fixation during the visual probe task, which is defined as the maintenance of visual gaze on a picture. Greater average gaze duration (in milliseconds) on food or alcohol pictures versus matched control pictures is indicative of greater *duration attentional biases*. Third, greater proportion of initial fixations on food or alcohol pictures versus matched control pictures is indicative of greater *direction attentional biases.* All pictures used in the visual probe task came from previous attentional biases studies (see Castellanos et al., 2009; Field et al., 2004). Importantly, separate forms of attentional biases reflect differing attentional processes. Notably, duration and cognitive attentional biases reflect biases in maintained selective attention due to pictures being presented for a prolonged period of time (i.e., 1000ms). In assessing cognitive and duration attentional biases, individuals are able to shift attention freely between food or alcohol pictures and control pictures, with longer attention paid to and faster reaction times toward alcohol or food pictures indicating a bias in maintained selective attention. In contrast, direction attentional biases reflect biases in automatic selective attention (Castellanos et al., 2009; Ceballos et al., 2009; Field & Cox, 2008; Schoenmakers et al., 2008). Direction attentional biases assess immediate initial orientation toward either food/alcohol pictures or control pictures, with more frequent immediate initial orientation toward food/alcohol pictures reflecting a bias in automatic selective attention.

Alcohol odorants. Beer and water odors were delivered to participants via an 8-channel air dilution olfactometer (Bragulat et al., 2008; Kareken et al., 2004), which was controlled using the Dasylab software and a Personal Daq/56 module (IO-Tech, Inc., Cleveland, OH). Small polytetrafluoroethylene tubes were used to deliver air to the participants' nose at 2.0 liters per minute (lpm), which consists of a constant 1.0 lpm stream and a 1.0 lpm stream of an odorant. The primary manipulation condition involves exposure to beer odorant (Bud Light, 4.20% ABV), while the control condition involves exposure to water odorant.

Problematic food consumption. Problematic food consumption was assessed using the Three Factor Eating Questionnaire-R18 (TFEQ-R18; Karlsson et al., 2000). The TFEQ-R18 (α = 0.83) was calculated as a mean value, with higher values indicating higher problematic food consumption.

Procedure

Participants first completed baseline measures of food and alcohol cravings and then completed four randomly ordered experimental trials, in which participants were exposed to odors (water or alcohol) and completed visual probe tasks (food or alcohol pictures). During each trial, participants were first exposed to an odor and then rated the odor in terms of intensity, pleasantness, and representativeness. The remainder of the trial followed this sequence: (1) participants heard the "ready" "sniff" command, during which a 2-second odor was delivered, followed by a tone indicating that they could exhale; and (2) participants then completed the visual probe task a total of five times (Bragulat et al., 2008; Kareken et al., 2004). This sequence was repeated a total of six times, with participants being exposed to 30 visual probe tasks (30 food or alcohol pictures paired with control pictures) and 6 odors per trial. Before each trial, participants were positioned (24 inches from the monitor) and had their eye movements calibrated. Cravings were re-rated after each experimental trial. After completing all experimental trials, participants self-reported their level of past problematic food consumption.

During all experimental trials, participants were exposed to odors (alcohol and water) and pictures (food and alcohol). Importantly, because the pictures were utilized in measuring attentional biases, we were able to examine the effect of odors on food attentional biases. However, food cravings were assessed at the end of each experimental trial, at which point participants were already exposed to all odors and pictures. Due to this, we were not able to directly examine the effect of odors on food cravings; instead, because of the study's design, we examined the effect of different combinations of odors and pictures on food cravings.

Results

Analyses

We used paired samples t-test to examine sample characteristics and odor ratings. We used repeated measures analyses of variance (ANOVAs) and planned post-hoc Sidak tests to examine the effect of odors (water vs. alcohol) on cravings and attentional biases. Partial eta squared was used to quantify effect size (Lakens, 2013). *P*-values and confidence intervals determined whether pairwise comparisons with post-hoc Sidak tests are significant. We used multiple regressions to examine the associations of alcohol odor elicited food cravings and attentional biases with self-reported problematic food consumption. Cravings and attentional biases were entered in separate regression analyses due to strong inter-correlations (rs = 0.86 to 0.92, all $ps < 0.001$).

Preliminary analyses

Participants (n = 77; 51.9% female, 77.9% non-college students, 83.1% Caucasian) had a mean age of 30.84 (SD = 9.46, *Range* = 18 to 54; see Table 1, INSERT HERE). Across the two trials involving alcohol pictures, the beer odor was rated to be more intense, pleasant, and representative compared to the water odor (*ps* = 0.001 to 0.03). Across the two trials involving food pictures, the beer odor was rated to be more intense and representative than the water odor, but the difference in pleasantness fell short of significance (*ps* = 0.001 to 0.07). Mean levels of odor ratings and key study variables are presented in Table 2 (INSERT HERE).

Manipulation check: Effects on alcohol cravings and attentional biases

As expected, the effect of odors on alcohol cravings was large and significant, regardless of the visual probe picture condition, $F(4, 268) = 17.06$, $\eta_p^2 = 0.20$, $p < 0.001$ (see Figure 1). Alcohol cravings following alcohol odors and alcohol pictures were higher than alcohol cravings following water odors and alcohol pictures (95% CI = 0.32 to 4.12, $p = 0.01$). Similarly, alcohol cravings following alcohol odors and food pictures were higher than alcohol cravings following water odors and food pictures (95% CI = 0.15 to 4.64, $p = 0.03$).

In the alcohol visual probe picture condition, odors had: (1) a non-significant effect on alcohol cognitive attentional biases, $F(1, 62) = 0.002$, $\eta_p^2 < 0.001$, $p = 0.96$; (2) a significant medium effect on alcohol direction attentional biases, $F(1, 61) = 8.31$, $\eta_p^2 = 0.12$, $p = 0.01$; and (3) a significant medium effect on alcohol duration attentional biases, $F(1, 62) = 6.20$, $\eta_p^2 = 0.09$, $p = 0.02$ (see Figure 2). Alcohol direction attentional biases were higher following alcohol odors than water odors (95% CI = 1.09 to 6.02, $p = 0.01$). Alcohol duration attentional biases were higher following alcohol odors than water odors (95% CI = 0.01 to 0.13, $p = 0.02$).

Primary hypotheses: Effects on food cravings and attentional biases

Odors had a medium significant effect on food cravings, regardless of the visual probe picture condition, $F(4, 280) = 6.36$, $\eta_p^2 = 0.08$, $p < 0.001$. There was a significant increase in food cravings from baseline when either alcohol or water odors were paired with food pictures

(95% CIs = -5.46 to – 0.25, *ps* = 0.003 to 0.02), but not when alcohol and water odors were paired with alcohol pictures (95% CIs = -3.42 to 1.36, *ps* = 0.45 to 0.95). Regardless of the visual probe picture condition, alcohol odors did not significantly increase food cravings relative to water odors (95% CIs = -2.27 to 2.84, *ps* = 0.87 to 0.99). Figure 1 summarizes these results (INSERT HERE).

In the food visual probe picture condition, odors had a large significant effect on food duration attentional biases, $F(1, 63) = 16.11$, $\eta_p^2 = 0.20$, $p < 0.01$. Food duration attentional biases were higher following alcohol odors than water odors (95% CI = 0.05 to 0.16, $p < 0.001$). In contrast, odors did not have a significant effect on food cognitive attentional biases, $F(1, 67) = 0.15$, $\eta_p^2 = 0.002$, $p = 0.70$, or food direction attentional biases, $F(1, 62) = 2.40$, $\eta_p^2 = 0.04$, $p = 0.13$. Figures 2 summarizes these results (INSERT HERE).

Exploratory Analyses: Associations with self-reported problematic food consumption

Problematic food consumption was positively associated with food cravings paired with alcohol odors and pictures ($\beta = 0.25$, b = 0.01, $p = 0.03$) and food cravings paired with alcohol odors and food pictures ($\beta = 0.35$, b = 0.02, $p < 0.001$). Problematic food consumption was also positively associated with alcohol odor elicited food direction attentional biases ($\beta = 0.25$, b = 0.01, $p = 0.04$) and duration attentional biases ($\beta = 0.24$, b = 0.42, $p = 0.04$). No other relationships reached significance ($\beta s = 0.03$ to 0.10, bs = 0.00 to 0.13, *ps* = 0.38 to 0.84).

Discussion

The current study findings partially support that alcohol odors, in isolation or when combined with pictures, can influence food cravings and attentional biases. Importantly, exposure to alcohol odors increased food cravings, but only when the odors were also paired with food (but not alcohol) pictures. On the other hand, alcohol odors increased food duration attentional biases, but not food direction or cognitive attentional biases. Interestingly, these food cravings and attentional biases were associated with higher self-reported problematic food consumption. These findings serve as a preliminary first step in supporting the viability of a model wherein alcohol cues influence problematic food consumption by eliciting food cravings and food attentional biases.

We found that alcohol odors increased food cravings, but only when alcohol odors were combined with food pictures. In contrast, a combination of alcohol odors and pictures did not influence food cravings. Furthermore, when combined with water odors, food pictures did not significantly increase food cravings as compared to alcohol pictures. These findings extend on prior findings indicating that (1) alcohol cues elicit increased alcohol cravings (Smith-Hoerter et al., 2004), (2) food cues elicit increased food cravings (Fedoroff et al., 2003; Harvey et al., 2005), and (3) non-food cues have no effect or negative effect on food cravings (Kemps & Tiggemann, 2007; Kemps &Tiggemann, 2013). When presented alone, alcohol cues can be considered non-food cues and should subsequently have no effect on food cravings. Instead, food cravings might only be elicited through a combination of alcohol odors and food pictures. Of note, this is more reflective of naturalistic environments, wherein alcohol and food cues are often encountered together and might conjunctively influence food consumption by eliciting food cravings (see Caton et al., 2007).

We found that alcohol odors increased food duration attentional biases, but not food cognitive and direction attentional biases. There are two viable explanations for these inconsistent findings. First, separate forms of attentional biases likely tap into separate aspects of attentional processes, which are likely differentially influenced by cues (Castellanos et al., 2009; Ceballos et al., 2009; Field & Cox, 2008; Schoenmakers et al., 2008). Notably, study findings suggest that food and alcohol co-consumers might demonstrate alcohol odor elicited biases in maintained selective attention (duration but not cognitive attentional bias) and automatic selective attention (direction attentional bias) toward food pictures over matched control pictures. Second, measurement issues could explain why alcohol odors increased food duration attentional biases, but not food cognitive attentional biases. Importantly, eye movement measures sample attention continuously, and are a more sensitive and accurate index of attentional biases compared to visual probe tasks (Castellanos et al., 2009; Ceballos et al., 2009; Field et al., 2004). Notably, visual probe tasks measure attentional biases in terms of reaction time (i.e., mouse clicks) and thus only provide a snapshot view of attention (Field & Cox, 2008). More importantly, performance on visual probe tasks is also influenced by factors unrelated to attentional biases—such as task-related strategic influences, averaging, and individual differences (see Conrey et al., 2005; Field & Cox, 2008; Tiffany, 1990).

In exploratory analyses, we found that problematic food consumption was associated with alcohol odor elicited food direction and duration attentional biases, but not food cognitive attentional biases. Furthermore, problematic food consumption was associated with food cravings elicited by both food pictures and alcohol pictures combined with alcohol odors. Notably, these findings suggest that the effect of alcohol odors (in isolation or when combined with pictures) may be a marker of problematic food consumption. Furthermore, study findings suggest that inconsistencies in the disinhibiting effect of alcohol on food consumption (Caton et al., 2007; Christiansen et al., 2016) may be partially due to the influence of cue elicited food cravings and attentional biases on food consumption. Naturally, limitations associated with self-report measures and the study's partially cross-sectional design preclude firmer conclusions about causal direction and inferences about study findings. Future work should measure food consumption following alcohol cue exposure in a well-controlled laboratory setting.

The present study has limitations that should be addressed in future studies. In addition to having a low level of problematic food consumption, our sample was also healthy, homogeneous, and young; as such, study findings should be examined in more diverse samples and in clinical samples. Additionally, study design factors might have limited study findings—including the use of self-report measurements and the potential for carryover effects. Moreover, exposure to pictures during the visual probe tasks might influence cravings and consequently confound the effect of odors on cravings. However, the combined effects of pictures and odors may be more reflective of the effects of odors because odors are stronger than pictures in eliciting cravings (Drobes et al., 2001; Hawk et al., 2004). Finally, although the sample was chosen specifically to include those who co-consume beer and food in order to maximize power to detect effects, the effect of alcohol odors may only be specific to co-consumers and may not generalize to individuals who do not engage in co-consumption. Of note, the effect of alcohol odors on food cravings and attentional biases may be secondary to months or years of behavioral pairing of food and alcohol, as would be suggested by classical conditioning models (Castellanos et al., 2009; Powley, 1977; Siegel, 1983; Wardle, 1990).

This study is the first to provide key evidence that alcohol odors (in isolation or when combined with food pictures) could influence food cravings and attentional biases, both of which have been associated with increased food consumption (Jansen, 1998; Shafran et al., 2007; Smeets et al., 2008; Wardle, 1990). In this way, our findings provide preliminary support for the theory that alcohol cue exposure might increase food consumption, even in the absence of alcohol's pharmacological effects. If true, this would suggest that simply limiting alcohol intake is not an effective way to avoid increased food consumption; instead, simply being in the context of alcohol cues could also influence food consumption. As such, study findings serve as a first step in a program of research aimed at elucidating how alcohol influences food consumption. Even though preliminary in nature, future studies can expand on the present study's findings in the following ways: (1) examining whether food cravings and attentional biases following alcohol cue exposure would result in increased in vivo food consumption; (2) measuring physiological responses to alcohol cues; (3) recruiting a clinical sample of co-consumers; and (4) examining whether it is feasible to modify cue elicited responses to reduce co-consumption. Moreover, despite the small sample size, this study is the first to document potential effect sizes of alcohol odors on food cravings and attentional biases, which is important for the design of future research in this area.

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Declaration of Conflicting Interests

All authors declare that there is no conflict of interest.

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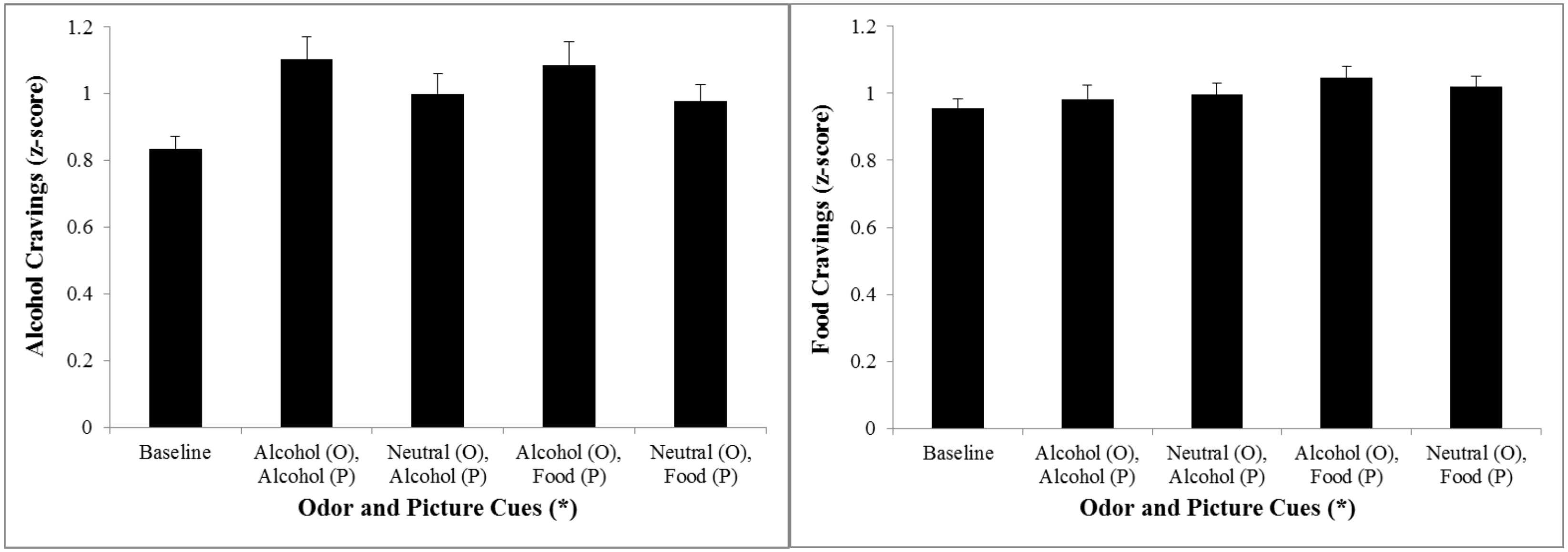
Table 1. Participant Characteristics

Continuous Variables	***M***	***SD***	***Range***	**Categorical Variables**	***Frequency***	***Percentage***
Age	30.84	9.46	18-54	**Gender**		
				Male	37	48.1
Problematic Eating	2.27	0.4	1.30-3.60	Female	40	51.9
				Race		
				Caucasian	64	83.1
				African	8	10.4
				Hispanic	2	2.6
				Asian	1	1.3
				Other	2	2.6

Table 2. Key Study Variables across Trials

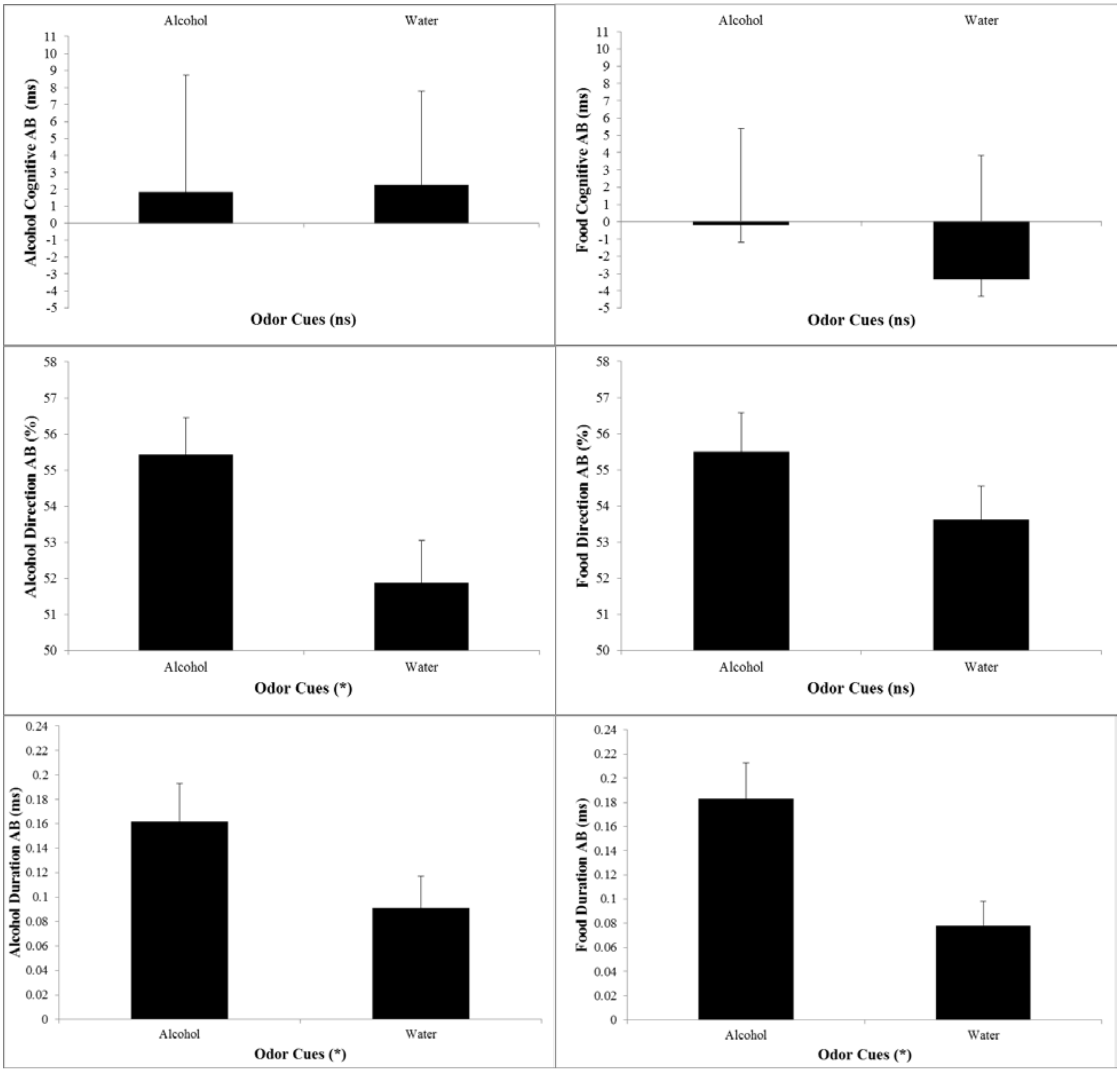
	Trial 1		Trial 3		
	M	***SD***	***M***	***SD***	***p-value***
Odor Intensity	2.87	0.80	1.35	0.66	<0.001
Odor Pleasantness	2.94	0.63	2.71	0.68	0.03
Odor Representativeness	3.16	0.77	1.55	0.70	<0.001
Alcohol Cravings	24.01	12.11	21.79	10.81	0.01
Food Cravings	34.44	10.93	34.92	10.17	0.99
Alcohol Cognitive Attentional Biases	1.84	54.75	2.27	43.62	0.96
Alcohol Duration Attentional Biases	0.16	0.24	0.09	0.21	0.02
Alcohol Direction Attentional Biases	55.42	8.16	51.87	9.29	0.01
	Trial 2		**Trial 4**		
	M	***SD***	***M***	***SD***	***p-value***
Odor Intensity	2.90	0.83	1.38	0.72	<0.001
Odor Pleasantness	2.93	0.60	2.77	0.54	0.07
Odor Representativeness	3.20	0.65	1.85	1.56	<0.001
Alcohol Cravings	23.68	12.19	21.28	10.08	0.03
Food Cravings	36.65	10.37	35.75	9.97	0.87
Food Cognitive Attentional Biases	-0.18	45.93	-3.32	59.08	0.70
Food Duration Attentional Biases	0.18	0.24	0.08	0.16	<0.001
Food Direction Attentional Biases	55.50	8.62	53.62	7.35	0.13

Note. Trials: Trial 1-alcohol odors and alcohol pictures; Trial 2-alcohol odors and food pictures; Trial 3-water odors and alcohol pictures; Trial 4-water odors and food pictures.



Note. Likert scale used to assess food and alcohol cravings. Overall cravings were calculated by averaging mean cravings across the four trials. Z-scores were calculated by comparing mean cravings in each condition to overall cravings. Odor and Pictorial Cues: O-odorants; P-pictures. (*) denotes significant effect of odors on cravings.

Figure 1. Cravings across Trials.



Note. AB-attentional biases. ms-millisecond. %-percent. (*) denotes significant difference and (ns) denotes non-significant difference in attentional biases.

Figure 2. Attentional Biases across Trials.