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Generalised inhibitory impairment to appetitive cues: From alcoholic to non-alcoholic visual stimuli

Rebecca L. Monk [1]*, Adam Qureshi [1], Charlotte R. Pennington [2] & Iain Hamlin [1]

[1] Edge Hill University, St Helens Rd, Ormskirk, UK, L39 4QP

[2] Lancaster University, Bailrigg, Lancaster, UK, LA1 4YW

*Corresponding author: Email monkre@edgehill.ac.uk

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Abstract

Background: Prior research demonstrates that individuals who consume alcohol show diminished inhibitory control towards alcohol-related cues. However, such research contrasts predominantly alcoholic appetitive cues with non-alcoholic, non-appetitive cues (e.g., stationary items). As such, it is not clear whether it is specifically the alcoholic nature of the cues that influences impairments in inhibitory control or whether more general appetitive processes are at play. **Aims:** The current study examined the hitherto untested assertion that the disinhibiting effects of alcohol-related stimuli might generalise to other appetitive liquid stimuli, but not to non-appetitive liquid stimuli. **Method:** Fifty-nine participants (*Mage* = 21.63, *SD* = 5.85) completed a modified version of the Stop Signal Task, which exposed them to visual stimuli of three types of liquids: Alcoholic appetitive (e.g., wine), non-alcoholic appetitive (e.g., water) and non-appetitive (e.g., washing-up liquid). **Results:** Consistent with predictions, Stop-signal reaction time was significantly longer for appetitive (alcoholic, non-alcoholic) compared to non-appetitive stimuli. Participants were also faster and less error-prone when responding to appetitive relative to non-appetitive stimuli on go-trials. There were no apparent differences in stop signal reaction times between alcoholic and non-alcoholic appetitive products. **Conclusions:** These findings suggest that decreases in inhibitory control in response to alcohol-related cues might generalise to other appetitive liquids, possibly due to evaluative conditioning. Implications for existing research methodologies include the use of appetitive control conditions and the diversification of cues within tests of alcohol-related inhibitory control.

Key words: Inhibitory control; Disinhibition; Context, Alcohol-related cues, Appetitive cues; Stop Signal

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1.0 Introduction

A breadth of research suggests that individuals who consume alcohol show impaired inhibitory control towards alcohol-related stimuli, in both clinical (Kreusch et al., 2013; Roberts et al., 2014; Wiers et al., 2002) and non-clinical samples (Jones & Field, 2015; Wilcokson & Pathos, 2015). For example, alcohol cue exposure has been found to decrease response inhibition towards alcohol-related stimuli (e.g., pictures of beer bottles) in contrast to neutral stimuli (e.g., office stationary – Duka & Townshend, 2004; Kreusch et al., 2013, a stool, bus or umbrella – Jones & Field, 2015; or alphabetical letters; Pennington et al., 2016). Similarly, heavy drinkers have been found to make more commission errors (false alarms) when neutral, non-appetitive no-go stimuli are super-imposed onto alcohol-related images (Petit et al., 2012). The heightened associative reward value of alcohol-related relative to neutral cues is believed to be responsible for decreases in inhibitory control, increases in attentional bias, and resultant increases in alcohol consumption (Volkow et al., 2008; Volkow et al., 2013). Research also suggests that the attending to and processing of alcohol-related stimuli might in fact become compulsory (Wilcokson & Pothos, 2015). This view is supported by dual processing models of addiction (c.f., Stacy & Wiers, 2010), which theorise that alcohol-related behaviours may be driven by both implicit (strong approach biases towards alcohol) and explicit (executive functioning) mechanisms. Therefore, heightened disinhibition may override reflective, controlled processes, such as effortful control and response inhibition, to influence alcohol consumption behaviours (Lavigne et al., 2017; Wiers et al., 2007). However, prior research investigating alcohol-related inhibitory control mechanisms has contrasted predominantly appetitive and non-appetitive (non-palatable/ingestible) cues, and it remains unclear whether utilising other appetitive products as stimuli would elicit the same findings. Expanding this

research to examine whether disinhibition to alcohol-related cues generalises to non-alcohol-related appetitive cues is therefore pertinent to our understanding of alcohol-related disinhibition.

Limited research has employed alcohol-related and neutral appetitive cues; such as beer bottles contrasted with water bottles or bottles of fizzy pop (e.g., Pulido et al., 2010), and has found that both heavy and lighter drinkers demonstrate diminished inhibitory control when responding to alcohol-related stimuli (Ames et al., 2014; Cavanagh & Obasi, 2015; Karoly et al., 2014). However, other empirical research has resulted in contradictory findings. For example, Adams et al. (2013) used an alcohol-shifting task to contrast appetitive alcoholic and non-alcoholic cues (e.g., beer bottles vs. water bottles). Findings indicated that although participants responded faster to alcohol-related lexical distractors after an acute dose of alcohol (assigned to 0.0-0.6mg/kg), they made more commission errors when responding to neutral, appetitive compared to alcohol appetitive image distracters. Moreover, Wiers and colleagues (2009) found that heavy alcohol drinkers showed a strong automatic approach bias for alcohol-related stimuli, but unexpectedly, also showed this bias towards other appetitive stimuli (i.e., soft drinks). In a modified version of the stop signal task, Nederkoorn and colleagues (2009) utilised neutral (shades of grey), soft drinks (e.g. cola), alcohol (e.g. beer) and erotic (e.g. a kissing couple) pictures. Against their hypotheses, there were no apparent differences in reaction time across stimuli type, and errors on Go-trials were greater for soda and erotic stimuli in contrast with neutral and alcohol-related stimuli. Additionally, their research did not allow for a comparison to be made between appetitive cues (both alcoholic and non-alcoholic) and non-appetitive, non-alcohol cues (with shaded colours being the main control category). This throws into question whether disinhibition in response to alcohol-related stimuli specifically reflects the alcohol-related content of these cues, or whether more general appetitive processes are at play.

In support of this assertion, Tapert et al. (2003) utilized a visual alcohol cue exposure paradigm and found that alcohol-using adolescents showed greater activation in posterior brain regions associated with appetitive functions and the formation of associations when viewing both alcoholic and neutral beverage images (ventral anterior cingulate and subcallosal, prefrontal, orbital, and limbic regions). Moreover, Monk et al. (2016a) found that drinkers exhibited generalised impaired inhibitory control towards both alcoholic and non-alcoholic appetitive stimuli when exposed to alcohol-related olfactory cues. Indeed, it is well documented that olfactory senses are strong modulators of appetite (Ramaekers et al., 2014; Rolls, 2004), and the incentive value of appetitive stimuli can heighten motivational states, as well as the desire to engage in subsequent consumption behaviours (Berridge, 2001; Volkow et al., 2008; 2013). Consequently, alcohol-related olfactory cues may influence general impairments in inhibition, with this spilling over from appetitive alcohol-related to neutral cues, potentially through evaluative conditioning. Literature from beyond the field of substance use and addiction provides further support to suggest that responses to unique stimuli (e.g., Baldi, et al., 2004; Mühlberger et al., 2014), including olfactory cues (e.g., Daly et al., 2001; Wadhwa et al., 2008), can become generalised to wider contexts and stimuli. For example, Wadhwa and colleagues (2008) found that individuals who sampled a drink high in incentive value (i.e., tastes good) showed an enhanced desire for other drink-related products, with this also spilling over to food-related products. However, aversive consumption cues - such as the unattractive smell of cleaning detergent - suppressed individual's craving responses and reward-seeking behaviours. This may suggest that high-incentive value consumption cues (i.e., palatable, appetitive cues) activate a general motivational state, prompting people to engage in greater approach tendencies for such cues (i.e., increased consumption, cravings), compared to low-incentive, non-appetitive cues which lead to approach avoidance.

By modifying the stimuli in a traditional stop signal task, the current study examined the impact of introducing appetitive cues (both alcoholic and non-alcoholic) and non-appetitive, non-alcohol cues on alcohol-related inhibitory control. We argue that the inclusion of non-alcohol-related cues that are appetitive, as opposed to non-appetitive (e.g., a stapler as used in prior research) provides a more appropriate control against which to assess inhibition towards alcohol-related products that are inherently appetitive. Further, we suggest that the addition of a third, non-appetitive cue proffers a greater control condition because it removes the potential confounds of comparing alcohol-related stimuli to neutral stimuli (e.g., beer vs. stationary), and between alcohol-related and neutral appetitive stimuli (e.g., beer vs. water). To examine this, participants completed a stop-signal task with three types of stimuli: Alcoholic appetitive (wine bottles), non-alcoholic appetitive (water bottles) and non-appetitive stimuli (washing up liquid). It was predicted that impaired response inhibition (i.e., longer stop-signal reaction times; SSRT) would be evident in both appetitive alcohol and non-alcohol-related cue conditions, but not in response to non-appetitive stimuli. This was underpinned by the rationale that non-appetitive cues, in contrast to appetitive cues, place fewer demands on inhibitory control. Secondary predictions on performance on Go trials were that response times would be faster and error rates lower for appetitive alcohol and non-alcohol-related cues relative to non-appetitive cues, possibly due to an excitatory response approach towards appetitive cues (c.f., Pennington et al., 2016).

2.0 Method

2.1 Participants

This online study was ethically approved by the Departmental Ethics Research Committee (DREC) at Edge Hill University. Sixty-two participants were originally recruited via an online recruitment website (SONA) and through campus advertisements asking for regular

drinkers. All were reimbursed £5 or equivalent course credit upon completion. A total of three participants were excluded from the final analyses due to outlying SSRT values, or had error rates above 80%, suggesting lower levels of inhibitory control and higher alcohol-related attentional biases (c.f., Wiers et al., 2002). A total of 59 participants were thus retained in the final analyses (42 female; M_{age} = 21.63, *SD* = 5.85; range 16 – 47)[1]. Post-hoc power analyses were conducted using G-Power 3.1 (Faul et al., 2009) and showed that the observed power for all main effects was 0.99 or above.

2.2 Measures

2.2.1 Self-report Measures

Alcohol Use Disorders Identification Test (AUDIT). The AUDIT (Saunders et al., 1993) was used to measure hazardous drinking patterns and reliability was satisfactory (Cronbach's α = 0.73). Participants' mean AUDIT score was 8.37 (*SD* = 4.77), which is marginally higher than the cut-off for clinical assessment (scores of 8 or more are deemed to indicate hazardous or harmful alcohol use; Babor et al., 2001; Saunders et al., 1993). Such scores are similar to other research using predominantly UK student samples (Clarke et al., 2015; Monk et al., 2016a; Moss et al., 2015). AUDIT-C scores, a measure of consumption within the AUDIT, had a mean of 4.86 (*SD* = 2.64), suggesting a slightly higher level of consumption when compared to the suggested cut-off for more detailed assessment of drinking and related problems (scores of ≥ 3; Bush et al., 1998). This fits the pattern of the mean found for the full AUDIT score.

[1] In the interest of transparency, a further 23 participants signed up to take part in the study but made no meaningful attempt to compete the study and thus provided no usable data. These included participants who completed only a few trials before termination (n = 6) and those who appeared to be disregarding the stop signal by repeatedly pressing the response keys without waiting for the response stimuli (n = 17).

Adult Temperament Questionnaire (ATQ). The effortful control sub-scale of the ATQ was utilised to assess trait levels of inhibition (Rothbart et al., 2000) and reliability was satisfactory Cronbach's $\alpha = 0.64$). The mean effortful control score was 4.21 (*SD* = 4.93), similar to that found by Evans and Rothbart (2007).

2.2.2 Inhibitory Control Measure

Stop Signal Task (SST). The structure of the stop-signal task followed that used by Zack et al. (2011). In this task, participants were required to make a semantic decision as to whether or not the stimulus presented in each trial was appetitive (i.e., palatable or of high incentive value c.f. Berridge, 2001) in which case they were instructed to press 'Q', or non-appetitive (i.e., non-palatable or of low incentive value), in which case they were instructed to press 'P'. Equal numbers of appetitive images (68 alcoholic and 68 non-alcoholic liquids – bottles of wine and water, respectively) and non-appetitive images (136; washing up liquid) were shown. Images were different colours but were matched in terms of size, luminosity and all branding was removed. A pilot study ($n = 77$) indicated that participants were able to distinguish between the appetitive and non-appetitive nature of these cues, with valence ratings of washing up liquid being significantly lower than that of both alcohol and non-alcohol images (p's < 0.01), as well as arousal ratings being significantly lower than alcohol images ($p < 0.01$). Arousal ratings for washing up liquid and non-alcohol images were not significantly different ($p = 0.43$). Examples are shown in Figure 1.

INSERT FIGURE 1 HERE

Participants completed a total of 272 trials (including 16 trials in an initial practice block, which were excluded from the final analyses). The 256 experimental trials were split into

eight blocks of 32 trials[2]. The stop-signal (SS) was presented randomly on 25% of trials. The procedures for Go and Stop trials are shown in Figure 2. On Stop trials, a 1000Hz tone was presented for 100ms at a variable delay after the onset of the Go stimulus. A dynamic tracking procedure (one for each visual stimulus category) varied the SS delay (time between the onset of Go and Stop signals) dependent on the participant's response. Specifically, correct responses resulted in the SS delay increasing by 50ms (making the task more difficult), whereas incorrect responses resulted in the SS delay decreasing by 50ms (making the task easier). Across 17 Stop trials for both appetitive stimuli, and 34 for the non-appetitive stimulus, the tracking procedure varied SS delay. Stop trial accuracy was approximately 45% for all visual stimuli types, close to the expected ideal value of 50% inhibitory success from the tracking procedure.

SSRT was calculated for each of the three types of stimuli (alcoholic appetitive, non-alcoholic appetitive, non-alcoholic non-appetitive) by subtracting participants' median stop signal delay (SSD) from their median response to go trials (where no stop signal is presented). Thereby higher SSRT values are indicative of lower inhibitory control (Band et al., 2003)[3].

INSERT FIGURE 2 HERE

2.3 Procedure

[2] The current study utilised the fewest amount of trials recommended by Zack et al. (2011) in light of pilot research which indicated that participants rated task length as an important factor in deterring participation from online studies. Indeed, pilot testing used 64 stop trials for the non-appetitive stimuli, and 32 stop trials for both appetitive stimuli categories. However, the testing length associated with this appeared to result in substantial participant drop out in the latter stages of the experiment. The decision was therefore taken to halve both the number of trials and the number of stop trials. There was no performance feedback for participants to monitor their performance, as per Zack et al. (2011), and there was no jitter on the inter-trial interval (ITI).

[3] For SSRT tasks which use dynamic tracking procedures, the mean method is primarily used relative to the integration method (used in fixed SSD procedures; Matzke et al., 2013). The median SSRT measure is equivalent to the mean SSRT measure when the distribution is symmetrical, which is the case within the current study (Band et al., 2003).

Participants were instructed to partake in this online study in a quiet location with access to a computer keyboard to ensure that mobile participation was prohibited[4]. They were asked not take part if they had consumed alcohol within the last 24 hours, in accordance with research showing that alcohol consumption can enhance the disinhibiting effects of alcohol-related cues (e.g., Weafer & Fillmore, 2015), or if they had ever received medical treatment due to concerns expressed about their drinking practices (also confirmed by their responses to the AUDIT). The webpage worked on all modern laptops and desktop browsers, including Internet Explorer 9 and above.

Participants provided informed consent before being provided with task instructions. Participants were instructed to respond to stimuli, apart from when a stop signal (an auditory tone) was presented (at an initial delay of 50ms) after presentation of the visual stimuli. They completed 16 practice trials before continuing onto 8 blocks of 32 critical trials. Breaks between blocks were provided for 60 seconds to prevent fatigue. Upon completion, participants completed an online version of the AUDIT and ATQ. These questionnaires were the final component of the study in order to ensure that participants did not become aware of the experimental aims and adjust their behaviour accordingly (c.f., Davies & Best, 1996). A unique six-digit code was generated for participants to collect their remuneration. All data from the online study were e-mailed to a secure e-mail address, with no identifying characteristics tied to this data.

2.4 Analytic Strategy

[4] The online version of this task was designed to run in accordance with validated, laboratory-based version of the stop signal task (Zack et al., 2011) it has been demonstrated that any slowing of recorded reaction times between online and E-Prime tasks is negligible (no more than 100ms - see Reimers & Stewart, 2015). An online version of this task was also selected in light of the increasing uptake of this method in the study of alcohol-rated inhibitory control (e.g., Jones & Field, 2015) and the benefits afforded to data collection (c.f., Casler et al., 2013)

A series of three-way repeated-measures Analysis of Variance tests (visual stimuli; alcoholic appetitive, non-alcoholic appetitive, non-appetitive) were conducted on Go-Trial error rates and reaction times (RT), stop-trial accuracy and Stop Signal Reaction Times (SSRT). Significant main effects were elucidated using Bonferroni-corrected pairwise comparisons. Self-reported alcohol consumption (AUDIT) and trait effortful control were then added to these analyses separately to assess their independent contributions to inhibitory control. Specifically, AUDIT scores were included as a covariate in line with research demonstrating the association between heavy drinking and deficits in response inhibition (Field et al., 2010). Effortful control (E.C) was entered based on the rationale that those with higher trait E.C may be better able to inhibit their responses (Muraven & Baumeister, 2000). Moreover, research has suggested that alcohol misuse may rely on the interplay between automatic (e.g., strong approach biases) and controlled (executive functioning) processes (Lavigne et al., 2017; Wiers et al., 2007; Wiers et al., 2015), thus providing an additional rationale for the inclusion of reported alcohol consumption and E.C.

3.0 Results

3.1 Go-Trial Error Rate

There was a significant main effect of visual stimuli on error rates, $F(1.71, 98.92^{5}) = 9.07$, $p \leq .001$, $\eta_p^2 = .14$. Participants made significantly more errors when responding to the non-appetitive liquid stimuli compared to both alcoholic and non-alcoholic appetitive liquids, $p = .027$ and $p = .001$, respectively. The appetitive liquids did not differ significantly in error rate ($p = 0.43$). Adding total AUDIT scores, and E.C. as covariates removed the main effect of visual stimuli (both $p > .05$).

[5] Greenhouse-Geisser adjustments reported due to violation of Mauchly's Test of Sphericity ($X^2(2) = 10.81$, $p < 0.01$ and $X^2(2) = 10.79$, $p < 0.01$ respectively).

3.2 Go Trial reaction times (RT)

There was a significant main effect of visual stimuli on go-trial RT, $F(2, 116) = 17.85$, $p \leq .001$, $\eta_p^2 = .24$. Participants were significantly slower when responding to non-appetitive liquid stimuli compared to both alcoholic and non-alcoholic appetitive liquids, both *p*'s ≤ .001. There was no significant difference in reaction time between the two appetitive liquids ($p = .83$). Including total AUDIT scores and E.C as covariates resulted in no main effect of visual stimuli (both $p > .05$).

In light of the age and gender imbalances in the current sample, the analyses detailed throughout section 2.4 were also run using only females and then again using only younger participants (excluding the participants over the age of 21, $n = 5$). This was also deemed prudent in order to alllay concerns based on research that indicates that women may show a deficient response inhibition towards alcohol-related cues compared to men (Nederkoorn et al., 2009). Similarly, there has been limited evidence of age-related declines in taks measuring inhibiton (Kramer et al., 1994). These analyses revealed the same pattern of results as those reported above.

INSERT TABLE 1 HERE

3.3 SSRT

There was a significant main effect of visual stimuli on SSRT, $F(1.77, 102.55)^6 = 8.21$, $p = .001$, $\eta_p^2 = .12$. SSRTs were significantly faster to non-appetitive liquids relative to both alcoholic ($p = .043$), and non-alcoholic appetitive liquids ($p = .002$). SSRTs did not differ significantly between alcoholic and non-alcoholic appetitive liquids ($p = .42$). See Figure 3.

Adding AUDIT scores as a covariate resulted in a significant main effect of visual stimuli, though with a reduced effect size, $F(1.78, 100.96)$[7] $= 4.38$, $p < .05$, $\eta_p^2 = .07$). Including E.C removed the main effect of visual stimuli, $p > .05$. Descriptive statistics for Go Trial error rate, Stop Trial accuracy, Go Trial RT and SSRT are shown in Table 1.

INSERT FIGURE 3 HERE

4.0 Discussion

The current study examined whether impaired inhibitory control to alcohol-related stimuli may generalise to other appetitive stimuli, but not to non-appetitive stimuli. In line with experimental predictions, the present findings indicate that when appetitive products were the stop stimuli, SSRTs were significantly longer compared to non-appetitive stimuli. Moreover, participants were faster and less error-prone when responding to appetitive stimuli on go-trials compared to non-appetitive stimuli. These findings suggest that participants demonstrate impaired inhibitory control when required to inhibit their responses to appetitive cues during stop-signal trials, but show an automatic approach tendency towards these cues in go-trials (c.f., Pennington et al., 2016). Given that there were no apparent differences in SSRT between alcoholic and non-alcoholic appetitive products, these findings also suggest that disinhibition towards alcoholic cues may generalise to other appetitive non-alcoholic cues.

The present findings are broadly in line with other research in this area which indicates that individuals show increased disinhibition in response to alcohol-related pictorial stimuli (as opposed to neutral, non-appetitive; e.g., Kreusch et al., 2013; Also see research examining responses to alcohol-related cues on no go trials, which show these stimuli are distracting and

[7] Greenhouse-Geisser adjustments reported due to violation of Mauchly's Test of Sphericity ($X^2(2) = 8.01$, $p < 0.05$ and $X^2(2) = 7.74$, $p < 0.05$ respectively).

"hijack" attentional processing e.g., Albery et al., 2015). However, by utilising both alcohol-related and neutral appetitive items (e.g., wine, water), and comparing these to non-appetitive neutral stimuli (e.g., washing up liquid), it is hoped that the current research findings may provide further clarity to the literature. Nevertheless, the present findings are in apparent contrast to the unexpected findings reported by Nederkoorn et al. (2009). Here, a main effect was evident such that more Go errors were recorded when heavy drinkers responded to to (appetitive) non-alcohol-related cues (e.g., soda) and erotic pictures, in contrast to pure control (e.g., shaded colours) and (appetitive) alcohol-related cues (beer). There were also no apparent main effects of image type on SSRTs. The nature of the stimuli used here, in contrast to those used in the current study, may however offer some insight.

We postulate that the present research may provide support for the assertions of Monk et al. (2016a) that impaired inhibitory control can become generalised from alcohol to non-alcohol-related stimuli, but that this effect is limited to appetitive cues. This is supported by the finding that participants were less accurate and slower when responding to non-appetitive liquids on go-trials and showed a proportionately higher stop-signal delay. It is thus postulated that alcohol-related cues may have a heightened associative reward value (Volkow et al., 2008; 2013; Wadhwa et al., 2008), resulting in amplified disinhibition which generalises to other appetitive cues. Indeed, whilst not hitherto applied to the field of substance (mis)use, wider literature suggests that responses to unique stimuli (e.g., Baldi et al., 2004; Wadhwa et al., 2008) can generalise to other cues. Indeed, it has been suggested that high-incentive value consumption cues (i.e., palatable, appetitive cues) activate a general motivational state, prompting people to engage in greater approach tendencies for such cues (i.e., increased consumption, cravings) compared to low-incentive, non-appetitive cues which lead to approach avoidance (Wadhwa et al., 2008). Further examination of such suggestions is, nonetheless, strongly advised.

Controlling for self-reported alcohol consumption (AUDIT) removed the observed differences in go-trial reaction times and error rates between appetitive and non-appetitive stimuli, and also reduced the effect size for SSRT differences. This may support the assertion that the effects of alcohol-related imagery on inhibitory control spill over to non-alcohol-related appetitive stimuli, as if the effect was alcohol-specific, any reduction would only be expected for alcohol-related appetitive stimuli. The fact that the reduction is seen for both types of appetitive stimuli suggests that it may be alcohol consumption behaviour that triggers this spill-over effect.

Whilst purely speculative, these decreases in inhibitory control in response to alcohol-related cues may generalise to other appetitive liquids as a result of semantic linking between the alcoholic stimuli (e.g., vodka) and the non-alcoholic appetitive (e.g., orange juice, which could also contain vodka). Moreover, controlling for effortful control removed the main effect of visual stimuli on go-trial RT, accuracy and SSRT, suggesting that trait inhibition may account partly for differences observed. Greater effortful control may therefore allow individuals to better regulate their responses to appetitive stimuli, thus diminishing the contrast between appetitive and non-appetitive stimuli. This seems plausible given that effortful control serves to facilitate long-term goals and task accuracy (Muraven & Baumeister, 2000).

Such research represents a first step towards further exploration of this field, and more research is strongly recommended. Nevertheless, the current findings may have important pragmatic implications. First, they suggest that by contrasting alcoholic items with non-appetitive non-alcoholic stimuli (e.g. stationary), previous research might have provided an over-inflated measure of disinhibition to alcohol-related cues. Indeed, even research utilising other categories of stimuli (e.g. Nederkoorn et al., 2009) have not allowed for comparisons between consumable items that vary in terms of their (non) appetitive nature. Second, the

current findings suggest that this impaired inhibition may indeed generalise, which might be harnessed for intervention purposes. Specifically, participants in alcohol-related environments are naturally primed by alcohol cues (c.f. Albery et al., 2015). As such, non-alcohol-related appetitive alternatives may have an equal appeal to patrons, and the offering of such (non-alcohol-containing) drinks may serve to curb excessive alcohol consumption. Whilst the current findings only pertain to appetitive versus non-appetitive liquids, future research may also benefit from explorations of whether such spill over effects are also evident in response to other non-alcohol-related food types (e.g., high sugar foods which are also commonly associated with impaired inhibition and linked with obesity; c.f., Chamberlain et al., 2015).

As well as tempering the current propositions with the need for further exploration, there are also a number of methodological points that should be considered. First, bottles of alcoholic (wine) and non-alcoholic drinks (orange) were utilised as appetitive stimuli in the current study, whereas household products (washing up liquid) were employed as non-alcoholic, non-appetitive stimuli. We must be mindful that these products are used typically in different environments (e.g., pub/social vs. household environments) and additional context effects might therefore be important. For example, research indicates that testing people in different contexts may impact alcohol purchasing decisions (Monk et al., 2016c) and that the introduction of contextual alcohol-related imagery (a bar relative to a lecture theatre) can alter implicit alcohol-related cognitions (Monk et al., 2016b). Research has also demonstrated that contextual factors may be important determinants of inhibitory control (Monk et al., 2016a) and attentional bias to alcohol-relate cues (c.f., Albery 2015). Future research would therefore benefit from situating alcoholic and non-alcoholic cues into wider contexts, or testing participants in different environments (c.f., Monk et al., 2016a; 2016b; 2016c). Future research would therefore benefit from situating alcoholic and non-alcoholic

cues into wider contexts, or testing participants in different environments (c.f., Monk et al., 2016a; 2016b; 2016c).

Second, the present findings are based only on the use of the stop signal task, yet there are a great number of other paradigms available to researchers, including those that have perhaps been more frequently used with alcohol-related research, such as the Stroop test (c.f. Flaudias et al., 2013), as well as others such as the anti-saccade task (c.f., Noël et al., 2013) and the Go/No Go Association Test (c.f., Pennington et al., 2016; Petit et al., 2012). How one measures inhibitory control and the varying nature of these methodologies means that caution is needed when seeking to reliably generalise the present findings to other methodologies in this area. In a similar vein, care should be taken when seeking to generalise the current results to other, older populations, in which alcohol consumption levels may vary. There is a well-documented culture of drinking at amongst younger people, particularly those at university (Borsari & Carey, 2001) and it is consequently possible that baseline differences in inhibitory control may have been present in the current sample. No correlation was found between the difference in SSRT for alcohol and non-alcohol stimuli and AUDIT scores (though see Karoly et al., 2014). Nonetheless, additional research is advised to examine whether there is any change in such appetitive biases in clinical populations drinkers. Future research may also be advanced by measuring concurrent drug use, in light of research which suggests that stop accuracy may be affected by drug use (e.g., Fillmore & Rush, 2002).

Finally, whilst participants were asked to take part in the study in a quiet location, the online nature of this study means that we cannot be sure that external distractors or influences did not impact performance. Indeed, alcohol-related beliefs (Monk & Heim, 2013a; 2013b; Monk & Heim, 2014; Thrul & Kuntsche, 2015; 2016) and inhibitory control levels (Monk et al., 2016) have been shown to vary across different contexts and exposure to varying

contextual cues. Participants were also asked not to consume alcohol within 24 hours of taking part but, again, this was dependent on participant self-report as there were no objective measures of intoxication used, nor any measures of other drug use (e.g., cigarettes, cocaine or marijuana), which may further influence inhibitory control mechanisms (Pike et al., 2013; Weafer & Fillmore, 2015). Any such consumption could therefore have inadvertently affected the current results, yet it is hoped that such instances would be infrequent and that data screening procedures would have prevented any resulting large deviations from being included within the final analyses. These points relate to the nature of online testing, which mean that we must acknowledge certain limitations regarding our knowledge about the context in which texting took place.

4.1 Conclusion

Prior research has examined alcohol-related inhibitory control by contrasting drinker's responses to appetitive alcoholic stimuli (e.g., beer, wine) with neutral, non-appetitive stimuli (e.g., stationary items). Moreover, those that have utilised neutral, appetitive stimuli (e.g., fizzy pop and soda) have not employed a control condition of non-appetitive, liquid stimuli (e.g., washing up liquid). As such, it is unknown whether alcohol-related disinhibition might generalise to other non-alcoholic consumable cues, due to appetitive processing, but not to non-appetitive, non-consumable cues. The current study therefore examined the hitherto untested assertion that the disinhibiting effects of alcohol-related stimuli might spill over onto other appetitive, but not to non-appetitive liquid stimuli. Results suggest that decreases in inhibitory control in response to alcohol-related cues may generalise to other appetitive liquids, possibly as a result of semantic linking between the appetitive stimuli. In other words, the presentation of appetitive cues may activate a general motivational state, prompting people to engage in greater approach tendencies for such cues compared to low-incentive, non-appetitive cues. Further research is required to test such assertions but the current findings represent a first step

and may be used to inform future research and intervention approaches in this field. The diversification of the cues used in research in this area may thus be useful in the expansion of our knowledge in this area.

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Figure captions

Figure 1.

Left - Appetitive alcohol-related item; Right: Appetitive non-alcohol-related item; Bottom: Non-appetitive item

Figure 2.

Go trial (L) and Stop trial (R) procedures

Figure 3.

SSRT by visual stimuli type (ms; error bars = confidence intervals)

Table 1: Descriptive statistics for Go Trial RT (median, correct only), Go Trial Accuracy and Stop Trial Accuracy

	Consumable Alcohol	Non-Alcohol	Non-Consumable
		M (SD)	
Go Trial error rate	.18 (.21)	.17 (.20)	.20 (.19)
Stop Trial accuracy	.43 (.25)	.45 (.26)	.44 (.24)
Go Trial RT (median)	672.25 (108.46)	666.60 (112.39)	694.82 (104.90)
Stop-Signal RT	313.21 (63.72)	327.35 (76.47)	280.84 (89.98)