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

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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.

1. 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 and Field, 2015; Wilcockson and Pothos, 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 and Townshend, 2004; Kreusch et al., 2013, a stool, bus or umbrella – Jones and 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 (Wilcockson and Pothos, 2015). This view is supported by dual processing models of addiction (c.f., Stacy and 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

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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 and Obasi, 2016; 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 0.0–0.6 mg/kg), they made more commission errors when responding to neutral, appetitive compared to alcohol appetitive image distracters. Moreover, Weirs et al. (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 et al. (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) utilised 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, 2005), 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 et al. (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. 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 $\geq$3; Bush et al., 1998). This fits the pattern of the mean found for the full AUDIT score.

Adult Temperament Questionnaire (ATQ). The effortful control subscale of the ATQ was utilised to assess trait levels of inhibition (Rothbart et al., 2000) and reliability was satisfactory Cronbach's

[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).