Drug and Alcohol Dependence 175 (2017) 99–105

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Full length article

Selective attention moderates the relationship between attentional capture by signals of nondrug reward and illicit drug use

Lucy Albertella[a,b,*], Jan Copeland[b], Daniel Pearson[a], Poppy Watson[a,c,d], Reinout W. Wiers[c,d], Mike E. Le Pelley[a]

[a] School of Psychology, UNSW Sydney, Sydney, Australia
[b] National Cannabis Prevention and Information Centre, UNSW Sydney, Sydney, Australia
[c] Addiction Development and Psychopathology (ADAPT) lab, Department of Developmental Psychology, University of Amsterdam, Amsterdam, The Netherlands
[d] Amsterdam Brain and Cognition, University of Amsterdam, Amsterdam, The Netherlands

ARTICLE INFO

Keywords:
Attention
Substance use
Sign-tracking
Reward learning

ABSTRACT

Background: The current study examined whether cognitive control moderates the association between (non-drug) reward-modulated attentional capture and use of alcohol and other drugs (AOD).
Methods: Participants were 66 university students who completed an assessment including questions about AOD use, a visual search task to measure value-modulated attentional capture, and a goal-directed selective attention task as a measure of cognitive control.
Results: The association between the effect of value-modulated attentional capture and illicit drug use was moderated by level of cognitive control. Among participants with lower levels of cognitive control, value-modulated attentional capture was associated with illicit drug use. This was not the case among participants with higher levels of cognitive control, who instead showed a significant association between illicit drug use and self-reported impulsivity, as well as alcohol use.
Conclusions: These results provide support for models that view addictive behaviours as resulting from interaction and competition between automatic and more reflective processes. That is, the mechanisms that ultimately drive addictive behaviour may differ between people low or high in cognitive control. This has important implications for understanding the development and maintenance of substance use disorders and potentially their treatment and prevention.

1. Introduction

According to dual-process models of addictive behaviours (for a review, see Stacy and Wiers, 2010), problematic substance use arises when relatively automatic, impulsive processes begin to dominate reflective processes in addiction-related decision making. This imbalance is considered to arise primarily from repeated exposure to alcohol and/or other drugs (AOD), which (through various proposed mechanisms) acts to strengthen the influence exerted by automatic appetitive processes over behaviour, relative to that exerted by reflective processes. For instance, a number of models propose that repeated and heavy exposure to AOD can sensitise the automatic system via the operation of learning processes, rendering an individual especially susceptible to maladaptive control by drug-related cues (Robinson and Berridge, 2000; Wiers et al., 2007). Specifically, it has been argued that through repeated pairing of certain stimuli with the rewarding consequences of taking a drug, those previously neutral stimuli come to acquire *incentive salience*, subsequently attracting attention and evoking powerful approach responses in their own right (Berridge et al., 2009; Robinson and Berridge, 2000). Conversely, repeated exposures to AOD are proposed to weaken the reflective system, rendering it less able to oppose the influence exerted by the progressively stronger automatic system.

Aside from the long-term effects of substance use on both automatic and reflective processes, most models agree that premorbid individual differences in both type of processes can also influence the development and maintenance of addictive behaviours. Indeed, animal studies have shown individual differences in incentive salience attribution to play a role in predisposing individuals to addictive behaviours (Flagel et al., 2009). Likewise, individual differences in cognitive control are associated with future drug use (Squeglia et al., 2014). Especially strong support for dual-process theories comes from studies showing that individual differences in cognitive control moderate the relationship between automatic responding to AOD cues and actual AOD use. For

* Corresponding author at: School of Psychology, UNSW Sydney, NSW 2052, Australia.
E-mail address: l.albertella@unsw.edu.au (L. Albertella).

http://dx.doi.org/10.1016/j.drugalcdep.2017.01.041
Received 19 December 2016; Received in revised form 27 January 2017; Accepted 27 January 2017
Available online 30 March 2017

instance, Houben and Wiers (2009) found that positive implicit alcohol associations predicted alcohol use only in participants with poor response inhibition (i.e., weak cognitive control), whereas implicit alcohol associations were not related to future alcohol use among participants with good inhibitory control. Other findings have found a similar moderating effect of working memory on the ability of automatic AOD-related associations to predict later AOD use (Grenard et al., 2008; Thush et al., 2008), although some inconsistencies have been observed (for a review, see Wiers et al., 2015).

As suggested above, many studies have shown that AOD use and disorders are associated with abnormal attentional biases towards drug-related stimuli (see Field and Cox, 2008; for a review). Notably, recent studies have also linked AOD use and disorders with abnormal attentional biases for *non*-drug reward-related stimuli. One such study found that adolescents who reported higher levels of alcohol, tobacco, and cannabis use showed greater attentional engagement with cues that predicted non-drug reward (van Hemel-Ruiter et al., 2013). In another study, people in methadone treatment for opiate dependence showed significantly greater attentional capture stimuli related to non-drug reward in a visual search task, compared to healthy controls (Anderson et al., 2013). On the basis of this finding, Anderson et al. (2013) suggested that previous findings of attentional biases toward AOD-related cues in people with substance use disorders may in fact have arisen from a pre-existing attentional bias toward cues associated with reward in general. In other words, those individuals with a general predisposition towards automatic attentional capture by reward-related stimuli may be more susceptible to developing AOD-use disorders.

Individual differences in attentional capture by stimuli associated with non-drug reward may be considered to reflect a vulnerability within automatic processes, somewhat parallel to individual differences in attribution of incentive salience to reward-associated cues in the animal literature. Importantly, as mentioned above, animal studies suggest that such individual differences in attribution of incentive salience may indicate individual vulnerability to developing AOD-use problems. According to dual-process theories, the degree to which such individual differences in attentional capture by stimuli associated with reward actually influence behaviour would depend on the degree of cognitive control available to the individual. To date, however, studies have focused on automatic/implicit behaviour and attitudes toward AOD-related cues only; no existing study has explored whether cognitive control capacity might also moderate the relationship between attentional capture (by cues associated with non-drug reward) and AOD use. Such a moderating effect would strongly support existing dual-process accounts and extend them by highlighting the role of individual differences in attribution of incentive salience to cues associated with rewarding outcomes in general, and not just drug-related rewards.

Furthermore, existing studies exploring individual differences in attentional capture by stimuli associated with non-drug reward have used procedures in which participants are initially trained that orienting attention to the critical stimuli yields reward. The resulting attentional biases could therefore reflect instrumental conditioning of 'attentional habits', where reward reinforces the instrumental response of attending to a particular stimulus (Anderson, 2016; Le Pelley et al., 2016). As such, these studies cannot be considered to parallel animal studies of incentive salience attribution, which have typically used Pavlovian rather than instrumental conditioning procedures (e.g., Flagel et al., 2008) A visual search procedure recently developed by Le Pelley et al. (2015) allows us to overcome this issue. This study used a gaze-contingent procedure in which eye-movements were the means by which participants made their responses, and also provided the measure of attention. Eye-movements are tightly coupled with shifts of attention—an eye-movement to a given location is always preceded by a spatial shift of attention that location (Deubel and Schneider, 1996)—and so provide an excellent, online index of attention. On each trial of Le Pelley et al.'s (2015) procedure, participants have to make an eye-movement (a saccade) to a diamond-shaped target among circles, as quickly as possible. On most trials, one of the non-target circles is coloured, either red or blue (all other shapes are grey; see Fig. 1); hence this is an example of an additional singleton task (Theeuwes, 1991, 1992). The colour-singleton circle is referred to as the distractor. The colour of the distractor on a particular trial signals the magnitude of reward that is available. As such, these colours constitute Pavlovian signals of reward magnitude. Crucially, under these conditions the reward-predictive stimulus (the coloured distractor) is not the target to which participants must orient their gaze (or attention) in order to receive reward. In fact, the task is arranged such that, if participants look at or near the distractor prior to looking at the target, the reward on that trial is omitted. Nevertheless, participants are more likely to look at the distractor when it appears in the colour signalling high reward than the colour signalling low reward (Failing et al., 2015; Le Pelley et al., 2015; Pearson et al., 2015; Pearson et al., 2016), a finding referred to as *value-modulated attentional capture* (VMAC). Since participants are never rewarded for looking at the distractor in this task, there is no reinforcement for the instrumental response of looking at the distractor. Consequently, the VMAC procedure used by Le Pelley et al. (2015) provides a clearer demonstration of the modulation of attentional capture as a result of Pavlovian reward prediction.

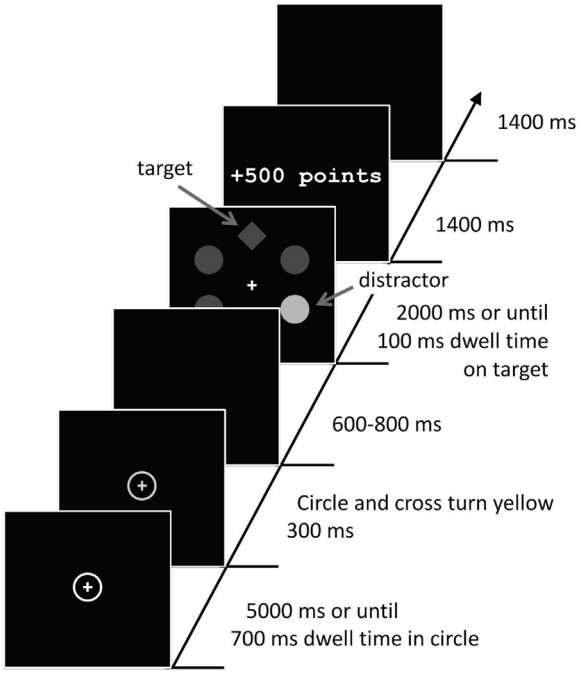

Fig. 1. Sequence of trial events in the value-modulated attentional capture (VMAC) task. On each trial, participants responded by moving their eyes to the diamond target in the search display. One of the non-target circles could be a colour singleton distractor. Fast, correct responses received monetary reward, depending on the distractor colour. A high-value distractor colour reliably predicted large reward (500 points); a low-value colour reliably predicted small reward (1 point); on distractor-absent trials, large and small rewards were equally likely. If any gaze fell within a small region of interest (ROI) surrounding the distractor (or, on distractor-absent trials, an equivalent ROI positioned around a randomly-chosen circle), the trial was deemed an omission trial and no reward was delivered.

The current study used the VMAC procedure to examine how (non-drug) reward-modulated attentional capture is related to AOD use in a sample of university students, and whether cognitive control (measured using a goal-directed selective attention task) moderates such a relationship. In this task, participants are required to select a target stimulus while ignoring a distractor stimulus. As the target and distractor stimuli are of similar salience in this task, performance may be considered a reflection of the extent to which participants are applying top-down, goal-directed attention to select the target and