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Internal reliability of the alcohol-related visual probe task is increased by utilising personalised stimuli and eye-tracking

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ABSTRACT

Background: In the current study, we investigated whether the internal reliability of the visual probe task measure of attentional bias for substance-related cues could be improved by incorporating eye-tracking methods and personalised stimuli.
Method: Sixty social drinkers completed two visual probe tasks: one with a broad range of different alcohol pictures, the other containing only images of the participants' preferred drink. Attentional bias was inferred from manual reaction times to probes replacing the pictures, and from the duration of eye movement fixations towards the pictures (gaze dwell time).
Results: Internal reliability was highest for personalised (versus general) alcohol stimuli, and for eye-tracking (versus manual reaction time) measures of attentional bias. The internal reliability of both reaction time ($\alpha = .73$) and gaze dwell time measures ($\alpha = .76$) of attentional bias for personalised alcohol stimuli was acceptable. Internal reliability of indices of attentional bias for general alcohol stimuli was inferior, although better for the gaze dwell time ($\alpha = .51$) compared to the reaction time measure ($\alpha = .19$). Attentional bias towards personalised stimuli was larger than bias to general stimuli, but only for the reaction time measure. There were no statistically significant associations between measures of attentional bias and alcohol consumption or craving.
Conclusions: Adopting personalised stimuli and eye movement monitoring significantly improves the internal reliability of the alcohol-related visual probe task.

1. Introduction

As predicted by several theories of addiction (Franken, 2003; Robinson and Berridge, 2001), attentional biases for substance-related cues are associated with individual differences in the frequency and quantity of substance use (see Field and Cox, 2008). However, there is some debate regarding the clinical relevance of attentional bias and treatment interventions based on it (Christiansen et al., 2015). The majority of studies in this area used one of two laboratory tasks: the visual probe task (VPT) and the addiction Stroop. In the VPT, a pair of pictures, one substance-related and the other neutral, is presented on the left and right of a computer screen. After pictures are removed from view, a probe (e.g., an arrow) is presented on either the left or right of the screen, and participants respond to the probe as quickly as possible. Faster responses to probes replacing substance-related compared to neutral images indicate an attentional bias for the substance-related cues. In the addiction Stroop, substance-related and neutral words are presented in coloured font, and participants must identify the colour in which words are printed. Slower colour-naming of alcohol-related compared to control words indicates an attentional bias.

In a reanalysis of their own datasets, Ataya et al. (2012) reported that the VPT task had poor reliability ($\alpha = .00$ to .50; mean .18), and the Stroop had poor to good internal reliability ($\alpha = .00$ to .98; mean .74). In response to this paper, we suggested that the poor reliability of the VPT may be attributable to specific features of the task (Field and Christiansen, 2012). First, reaction time measures of attentional bias provide only an indirect measure of attentional bias, a problem overcome by direct measurement of participants' eye movements during the task (see Ceballos et al., 2009; Field et al., 2006; Roberts and Fillmore, 2015; Rose et al., 2013). We reanalysed some of our own datasets in order to contrast internal reliability of reaction

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time and eye-movement measures and found that the latter had improved internal reliability (Field and Christiansen, 2012). Moreover, the superior internal reliability of eye-tracking measures may confer improved test–retest reliability (Marks et al., 2014a) and construct validity (Marks et al., 2014b; Miller and Fillmore, 2010).

An additional explanation for the poor internal reliability of these tasks is the stimuli used, which typically depicts a variety of different alcoholic beverages. Diverse stimuli may be a poor match for the drinking habits of individual participants. For example, one participant might regularly drink wine, but never consume other alcoholic beverages. Given that attentional bias is theorised to develop in proportion to the learned association between specific alcohol cues and the rewarding effects of alcohol (Berridge et al., 2009), we would expect attentional bias to be larger for personally relevant stimuli, as recently reported in a study that used a Stroop task (Fridrici et al., 2013). This inconsistency in responding to different stimuli would contribute to the low internal reliability of the VPT. Furthermore, personalised stimuli may also serve to improve the construct validity of these measures (Christiansen and Bloor, 2014; Houben and Wiers, 2009).

Our aim in the current study was to compare the internal reliability, magnitude and construct validity of reaction time and eye-movement indices of attentional bias for both general and personalised alcohol cues in a VPT. We compared the reliability of a general alcohol VPT which we have used in previously published studies (e.g., Christiansen et al., 2012; Field et al., 2011; Schoenmakers et al., 2008) with a personalised VPT that only presented pictures related to participants' preferred alcoholic drink. We hypothesised that an eye-tracking measure of attentional bias would have superior internal reliability compared to a reaction time measure, and that the personalised VPT would have superior internal reliability to the general VPT. We also predicted that the magnitude of attentional bias for personalised stimuli would be greater than for general stimuli, for both measures of attentional bias. Finally, we predicted that the eye-tracking measure of attentional bias for personalised alcohol stimuli would have the best construct validity, in terms of its association with individual differences in alcohol use and craving.

2. Method

2.1. Participants

An opportunity sample of 60 participants (39 female) aged between 18 and 27 years (mean 20.02 ± 2.04), were recruited via word of mouth and intranet advertising from students at the University of Liverpool. Participants consumed an average of 60.21 (±50.51) UK units in the 2 weeks prior to testing, and mean AUDIT scores were above the cut off for hazardous drinking (14.50 ± 4.86). Participants were invited to take part if they self-reported regular consumption of alcohol (at least one alcoholic drink per week), had never received a diagnosis of alcohol dependence, and did not wear eyeglasses, which were incompatible with the eye-tracking equipment. Before arrival in the lab we ensured participants had a preferred drink of either wine (red, white and rosé), beer, or vodka. Participants received course credit for their participation.

2.2. Materials

2.2.1. Pictorial stimuli. The VPT tasks used four picture sets each containing 14 pairs of alcohol-related and matched alcohol-unrelated (control) pictures (125 mm high × 125 mm wide). For the *general* VPT, alcohol pictures depicted a range of different types of alcohol and alcohol-related scenes (e.g., bottle and a glass of wine presented on a table, bottles of spirits, pints of beer). The alcohol-unrelated pictures were matched to the alcohol pictures on perceptual characteristics but they did not contain any alcohol-related cues (e.g., a bottle and a glass of water, a cup of tea, toast). Two pairs of pictures depicted cut-offs of faces (e.g., a wine glass or a water bottle raised to a mouth). This picture set was identical to that used in our previous research (e.g., Christiansen et al., 2012; Field et al., 2011; Schoenmakers et al., 2008). For the *personalised* VPT, three different picture sets were created: wine (red, white and rosé), beer, and vodka. We selected these drink categories on the basis of informal focus groups and results from a previous study (Christiansen and Bloor, 2014) that revealed these to be the most commonly consumed or preferred drinks among undergraduate students. As with the general VPT, pictures depicted alcohol-related scenes and each was matched with a picture that had no alcohol-related content. A unique set of control pictures, all depicting non-alcoholic drinks was generated for the personalised VPT, ensuring pictures within each pair were well matched on perceptual characteristics.

2.2.2. Questionnaires.

2.2.2.1. Timeline Followback (TLFB; Sobell and Sobell, 1990). The TLFB self-report questionnaire was used to retrospectively assess alcohol consumption. Participants had to estimate the number of alcohol units consumed over the preceding 14 days (one UK unit = 8 g of alcohol). We opted for a 14 day period because estimates based over longer periods may be less accurate (Hoeppner et al., 2010).

2.2.2.2. The Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993). The AUDIT was used to assess hazardous drinking; it consists of ten fixed-response questions regarding alcohol consumption and consequences of drinking. Scores on the AUDIT range between 0 and 40 with scores ≥8 or indicating hazardous or harmful alcohol use.

2.2.2.3. Desires for Alcohol Questionnaire – brief version (DAQ; Love et al., 1998). The DAQ is a 14-item alcohol craving scale scored on a 1–7 Likert scale, with higher scores indicative of higher craving. Given the inconsistency in the factor structure of the scale, we analysed the mean scale score (see Kavanagh et al., 2013).

2.2.3. Visual probe tasks (see Schoenmakers et al., 2008). The VPTs were programmed in Inquisit version 3 (Millisecond software, 2012). Each trial commenced with a white fixation cross presented in the centre of the screen for 500 ms. Immediately after this, a pair of pictures was presented for 2000 ms, one picture on the left of the screen and the other on the right, 60 mm apart. Immediately after this, one picture was replaced by a probe (a white arrow on a black background, pointing up or down). Participants had to respond to the orientation of the probe by pressing a key labelled up or down on a standard keyboard. The inter-trial interval was 500 ms.

Participants completed two versions of the VPT, one containing general alcohol-stimuli and one containing personalised alcohol-stimuli. Each task consisted of 68 trials in total. Participants first completed 10 practice trials in which neutral picture pairs were presented. The main task consisted of two buffer trials (neutral picture pairs) followed by 56 critical trials. The 14 picture pairs appeared four times each, with alcohol pictures on the left twice and on the right twice; visual probes replaced alcohol and control pictures with equal frequency. Trials were presented in a random order for each participant. Reaction time to probes was measured on each trial. Eye-movements were recorded during the 2000 ms of stimulus presentation using an eye-tracker (Applied Science Laboratories Eye-Trac D6, Bedford MA) at a sampling rate of 120 Hz. Each task therefore yielded two different measures of attentional bias, one based on reaction times and the other based on eye-movements.

2.3. Procedure

Testing took place in the Department of Psychological Sciences on the University of Liverpool campus. Each participant attended one 30 min session. Participants were breathalysed (all had BrAC of 0.00%) and then completed the questionnaire battery and then completed both the personalised and general VPT tasks, with task order counterbalanced. Participants completed the personalised VPT according to whether their favourite drink was beer ($N = 20$), wine ($N = 20$) or vodka ($N = 20$). Finally, participants were fully debriefed.

2.4. Data reduction and analysis

Reaction time data was subject to a trimming procedure (see Schoenmakers et al., 2008). Reaction times faster than 200 ms, slower than 2000 ms and then three standard deviations above the individual mean were removed prior to analysis. This led to the removal of 3.46% of data from the general VPT and 4.20% of data from the personalised VPT. We created attentional bias scores by computing mean reaction times to congruent probes (those that appeared in the same location as alcohol pictures) and incongruent probes (those that appeared in the same location as control pictures) before subtracting the congruent from incongruent reaction times, such that higher values indicate increased attentional bias. We did this separately for each pair of pictures, yielding 14 attentional bias scores based on manual reaction times, for each task.

For eye-movement data, we computed gaze dwell time as the total amount of time in milliseconds that participants spent fixating on each picture over the 2000 ms of each trial. Fixations were defined as a stable eye-movement within one degree of visual angle for 100 ms or longer, as in our previous research (e.g., Jones et al., 2012). Participants did not make any fixations on the pictures on 9.86% of trials in the general task and 12.94% of trials in the personalised task. Attentional bias scores were computed by subtracting mean gaze dwell time on neutral images from mean gaze dwell time on alcohol images. We did this separately for each pair of pictures, yielding 14 attentional bias scores based on gaze dwell times for each task.