The variable nature of cognitive control in a university sample of young adult drinkers.

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Abstract

The current study investigates the effect of task-irrelevant alcohol distractors on cognitive control and its interaction with heavy/light drinking in a group of young adult drinkers. It was hypothesised that alcohol distractors would result in a reduction of proactive control (reduced conflict adaptation) especially in heavy drinkers. 60 participants took part in a face-word version of the Stroop task preceded by an alcohol or neutral image. Light drinkers only showed a congruency effect which indicated a greater level of proactive control. Heavy drinkers showed a greater level of reactive control in which the conflict adaptation effect occurred with neutral images but not with alcohol images. Possible explanations are discussed.

1. Introduction

The current study investigates attentional control in young adult drinkers and how alcohol stimuli can affect attentional control. Previous research has focused on measuring how alcohol stimuli affect attentional control on single trials (Albery, Sharma, Noyce, Frings & Moss, 2015; Cox, Fadardi, & Pothos, 2006; Sharma, Albery, & Cook, 2001); the focus of the current study was to measure attentional control across multiple trials on a trial-by-trial basis.

Previous research has established that alcohol-related stimuli can hold the attention of heavy social and problem drinkers (Cox et al., 2006; Fadardi & Cox, 2006; Field & Cox, 2008; Lusher et al., 2004) as well as to hold attention long enough to affect subsequent trials (Clark, Sharma & Salter, 2015). Such carryover effects also occur with other addiction related stimuli (Sharma & Money, 2009; Waters et al., 2003; 2005) and negative emotional stimuli (Algom et al., 2004; Frings et al., 2010; McKenna & Sharma, 2004; Phaf & Kan, 2007). Neurocognitive models of selective attention highlight that attentional control can be adapted as the environmental demands change. A dominant account of such contextual modulation of attentional control is the conflict-monitoring theory (Botvinick, Braver, Barch, Carter & Cohen, 2001). This suggests that attentional control is engaged when conflicting information is detected, for example, when different streams of processing activate incompatible responses, such as incongruent trials in a Stroop task (Stroop, 1935). Conflict detection is thought to reduce the congruency effect (the difference between incongruent and congruent trials) by strengthening the task-relevant information. Thus the main prediction of this theory is that detecting conflict attenuates the congruency effect on subsequent trials (the conflict adaptation effect). This has been demonstrated using selective attention tasks such as the Stroop task (Kerns et al., 2004) and the Flanker task (Eriksen & Eriksen, 1974) where previous incongruent trials (compared to previous congruent trials) attenuate the interference on the current trial. Imaging results have implicated central executive control mechanisms, in particular, the medial prefrontal and dorsal anterior cingulate cortices in conflict detection (Botvinick et al., 2001; Kerns et al., 2004) and the lateral prefrontal cortex in cognitive control (Egner & Hirsh, 2005).

Executive control processes are also thought to be implicated in the attentional bias to alcohol stimuli, however, the central tenant of the conflict monitoring theory has not been tested in alcohol related research (see also Hotham, Sharma, & Hamilton-West, 2012). In particular how do alcohol-related stimuli affect cognitive control? Here we define cognitive control as the change in the trial-by-trial congruency effect that characterises the conflict adaptation effect (i.e. the attenuation of congruency effect on trials that follow incongruent than congruent trials). Padmala, Bauer and Pessoa (2011) have shown that prior irrelevant negative images can reduce the conflict adaptation effect on a face-word Stroop task. Our study followed closely the design used by Padmala et al., (2011) but used alcohol images rather than emotionally negative images. Theoretically it is suggested that motivationally salient stimuli reduce the resources available for top-down cognitive control. In the dual competition model Pessoa (2009) suggests a competition for limited executive control resources. This has been implemented in a connectionist model of adaptive attentional control by inhibition of the conflict detector (Wyble, Sharma & Bowman, 2008). More generally this describes a form of cognitive control referred to as reactive control (Braver, 2012). Reactive control emphasises the importance of recruiting attentional resources late in the selection process, after interference has occurred. This contrasts with proactive control that relies on attentional focus being set up in advance of the stimulus to inhibit automatic responses.

We hypothesise that in a group of heavy drinkers alcohol-related images are particularly salient and therefore will also show a reduction in top-down cognitive control demonstrated by a reduction in the conflict adaptation effect. We tested this in a group of undergraduate students, a group that is known for its drinking culture and hazardous drinking consumption (Gill, 2002; Heather et al., 2011; Davoren et al., 2015).

2 Method

2.1 Participants

Sixty undergraduate students (50 female and 10 males; Mean Age=19.90 years, Age range 18-37 years) from the University of Kent volunteered to take part in the study for course credit. They gave informed written consent and the study was approved by the Psychology ethics committee at the University of Kent. All participants reported to be an alcohol consumer. 35 participants were classified as heavy drinkers (26 females) and 25 as light drinkers (24 females), see table 1. The two groups did not differ significantly in Age $t(58)=1.34$, $p=.185$). All participants were fluent English speakers.

2.2 Materials

There were a total of 72 alcohol and 72 neutral coloured images, obtained from Google images and matched to be similar in size, shape and complexity. Five students rated these stimuli for alcohol relatedness to establish the alcohol stimuli used were ‘alcohol-related’ and the neutral stimuli were ‘not alcohol-related’. Alcohol images included drink related objects (e.g. alcohol bottles, beer cans, wine glass). Neutral images were of household objects, (e.g. kettle, pen, hair brush, bucket, candle).

Alcohol Use Disorder Identification Test (AUDIT)

Participants also completed a short questionnaire, the AUDIT (Alcohol Use Disorder Identification Test; Saunders et al., 1993) consisting of ten questions. The AUDIT is a validated instrument that measures hazardous alcohol use (Lunin et al., 2015).

2.3 Procedure

All participants were tested individually in a quiet room with a computer. Participants first read the information sheet, signed the consent form and then completed the AUDIT questionnaire. Once completed, the researcher returned to the room to provide more detailed instructions about the computerised task.

The study was programmed using Eprime, Version 2.10. Each trial began with a white fixation cross for 500ms followed by a face-word image (see Figure 1). The face-word image was of a male or female face (all with neutral expressions) overlaid with the words (female, FEMALE, male, or MALE) taken from Padmala et al., (2011)[1]. Participants were asked to ignore the word and respond only to the gender of the face. The face-word remained on the screen until a response was made using the keyboard (right index finger: ‘m’ for male and left index finger: ‘z’ for female). Once a response was given the face-word disappeared, followed by a 200ms blank interval before an alcohol-related or neutral image was presented for 500ms. Participants were asked to ignore the alcohol or neutral image.

Practice with the task (24 trials) was provided before the experimental trials. During practice (but not the experimental trials) a feedback (“correct”/”incorrect”) screen was displayed for 1000ms. A different set of stimuli were used during practice. The experimental trials (288 trials) consisted of six blocks of 48 trials. All conditions were randomly intermixed with the constraint that the trial order of each of the experimental conditions was (a) balanced in terms of previous and current trial congruency. (b) Half of the trials were preceded by a neutral image and half by an alcohol image. (c) The face or word did not physically match across successive trials to minimize priming effects (Mayr et al., 2003). As in Mayr et al., (2003) words were not alternated between the two genders but alternated in upper and lower case in successive trials. (d) On successive trials half the trials repeated and half switched in response. The 72 male and 72 female faces were repeated once and shown once preceded by an incongruent trial and once preceded by a congruent trial.

3. Results

Prior to analysis of the response latencies, the first trial of each block, error trials, trials immediately following an error, and trials with an RT exceeding 2000ms and less than 200ms were removed.

A mixed design ANOVA was performed with Group (heavy, light drinker) as a between participant factor, and Image type (alcohol, neutral), Previous congruency (congruent, incongruent) and Current congruency (congruent, incongruent) as within participant factors. Mean correct reaction times was the dependent variable. As in previous research a Stroop effect (an effect of Current congruency: RT to incongruent trials are longer than to congruent trials) is expected as is a conflict adaptation effect (an interaction between Previous congruency and Current congruency indicating reduced congruency effects when the previous trial is incongruent than when congruent). In addition it was hypothesised that the conflict adaptation effect would interact with Image type for heavy drinkers.

The analysis of the response latencies revealed a significant main effect of Current congruency, $F(1,58)=85.18$, $MSe=2433.55$, $p<.001$ (one-tailed), $\eta_p^2=.59$ and a Previous congruency x Current congruency interaction, $F(1,58)=3.66$, $MSe=839.10$, $p=.03$ (one-tailed), $\eta_p^2=.06$. In addition, we found that the conflict adaptation effect interacted with Group and Image Type as a significant 4-way interaction between Group x Image Type x Previous congruency x Current congruency, $F(1,58)=4.38$, $MSe=1755.83$, $p=.041$, $\eta_p^2=.07$ (see Figure 2). All other main and interaction effects were not significant (all F’s<2.06, p>.15).

Further analysis focused on the pattern of results within the two groups. Simple effects analysis indicated that for heavy drinkers the simple 3-way interaction between Image Type x Previous congruency x Current congruency was significant, F(1,34)=4.76, MSe=2063.67, p=.036, η_p^2=.12 (See Figure 2). This was due to a significant Previous x Current congruency interaction for neutral images, F(1,34)=9.16, MSe=1280, p=.005, η_p^2=.21, in which the current incongruent trial was faster when preceded by an incongruent trial than a congruent trial, p=.019 (this comparison was not significant for the current congruent trial, p=.08). The Previous x Current congruency interaction was not significant for alcohol images, F(1,34)=.47, MSe=1622.40, p=.496 η_p^2=.01. In contrast, for light drinkers the simple Image Type x Previous x Current congruency interaction was not significant, F(1,24)=.731, MSe=1319.72, p=.40, η_p^2=.03, but there was a simple main effect of Current congruency, F(1,24)=33.38, MSe=2932.86, p<.001, η_p^2=.58, that was not moderated by Previous congruency or Image Type (see Figure 2). Also, for light drinkers the simple Previous x Current congruency interaction for alcohol (F(1,24)=1.94, p=.176, η_p^2= .075) and neutral (F(1,24)=.03, p=.859, η_p^2=.001) images were not significant.

Analysis of the error rates (mean proportion) showed main effects of Current and Previous congruency. However, these were subsumed within the Previous x Current congruency interaction, F(1,58)=9.89, MSe=.002, p=.003, η_p^2=.15 These results are consistent with the conflict adaptation effect showing larger congruency effects in errors when the previous trial is congruent ($M_{congruent}$=.033, $M_{incongruent}$=.097), than when the previous trial is incongruent ($M_{congruent}$=.035, $M_{incongruent}$=.074) . The Previous x Current congruency interaction was not moderated by Image Type (p=.627) or Group (p=.420) nor by an interaction with Image Type x Group (F(1,58)=1.06, MSe=.002, p=.307, η_p^2=.02). There was an interaction between Group and Image Type (Low_Neutral:.054; Low_Alcohol:.055, High_neutral=.071, High_Alcohol=.060). All other effects were not significant (F's<2.81, p's>.1).

4. Discussion

This research investigates whether alcohol saliency affects cognitive control mechanisms in a group of university students characterised as heavy drinkers (hazardous levels of alcohol consumption) or light drinkers (non-hazardous levels of alcohol consumption). The main finding was that for heavy drinkers conflict adaptation decreased when an irrelevant alcohol image (compared to a neutral image) was shown in between the two face-word conditions. In addition, light drinkers only showed a congruency effect with no conflict adaptation effect. These findings indicate that heavy drinkers are sensitive to the stimulus context, whether that context is previous congruency (incongruent/congruent) or previous alcohol saliency (alcohol/neutral), whereas the light drinkers were able to prevent this previous context from affecting their responses. This describes a general greater reliance on bottom-up information processing in the heavy drinkers compared to the light drinkers.

The dual competition model (Pessoa, 2009) and the adaptive attentional control model (Wyble et al., 2008), which intends to explain an interaction between emotion and executive function, can be used to explain these results. These models propose that threatening stimuli divert attentional resources from executive control processes, in this case conflict detection in the Stroop task. By analogy, our results suggest that for heavy drinkers alcohol images compete for the same executive control processes that are activated by incongruent stimuli to reduce top-down cognitive control. This also suggests that a general slowing due to a carryover effect cannot explain these results as the slow down would have been equivalent for both subsequent incongruent and congruent trials. More broadly, the findings highlight that heavy drinkers behaviour can be characterised as a form of reactive control. These results are also consistent with a motivational account of attentional control. In particular that heavy drinkers may attribute threat to the alcohol images. There is much evidence to show that threatening stimuli can deplete attentional resources which in turn leads to a greater reliance on bottom-up processing (Eysenck et al., 2007). In the current study participants completed the AUDIT prior to taking part in the computerised task. It is therefore possible that filling out the AUDIT may have primed individuals possibly even increased their concerns over heavy drinking (Davies & Best, 1996). Future research will need to investigate whether the results reported here generalise to a situation where such priming is not activated.

The pattern of results for light drinkers was different. Their response latencies were affected only by current congruency, indicating that light drinkers were able to filter out the previous context, whether the previous context was alcohol-related or congruency related. This pattern is consistent with a more proactive control of the previous context. It suggests that light drinkers may have greater attentional resources that enable them to reduce the impact of the previous context. The greater attentional resources may be related to the lower motivational significance of the alcohol stimuli. Although this may explain the insensitivity to the alcohol saliency it does not explain the insensitivity to the prior congruency. This is because if the alcohol images do not draw on additional executive control resources then conflict adaptation effects would still be expected because conflict (detecting that a trial is incongruent) is present under both neutral and alcohol conditions. One possibility for future research would be to explore the effects of mood as positive mood has been shown to reduce conflict adaptation effects (van Steenbergen et al., 2010; Schuch & Koch, 2015). It is possible that the lack of conflict adaptation in light drinkers may have been because this group were in a more positive mood than the heavy drinkers.

The greater reliance on reactive control in heavy drinkers illustrates not only that alcohol-related cues can capture the attention of heavy drinkers but also that there are consequences for other cognitive processes that are involved in the balance between top-down and bottom-up processing. The results also highlight the greater influence of the environmental context in heavy drinkers. Although heavy drinkers were exposed to alcohol-related images it would be interesting to explore other types of environmental contexts, for example, what are the effects of working in a bar, do nonvisual cues (e.g. smell) have the same effects as visual cues, do different types of environmental contexts have different consequences for attentional bias to alcohol and cognitive control mechanisms? Interestingly, Albery et al., (2015) have shown that heavy drinkers' attentional bias to alcohol stimuli was not affected by the level of exposure to working in a bar. However, in light drinkers the passive exposure to working in a bar increased the attentional bias to alcohol. Whether this passive form of exposure in light drinkers would have the same consequences for cognitive control processes as they do for heavy drinkers, where they are more actively engaged with alcohol stimuli, would be interesting to explore.

There are a number of limitations to this study. The majority of the sample were females so it is possible that the results do not generalise to males. In addition the majority of the males were in the heavy drinking group. In a recent study Yarmush et al., (2016) showed that alcohol cravings were affected by an interaction between the exposure to alcohol cues and impulsivity in females but not in males. This suggests that males may be less sensitive to the exposure to alcohol cues and possibly therefore, the effects of the previous alcohol context on conflict adaptation may be diminished. This would also be consistent with female (compared to male) heavy drinkers interpreting the alcohol stimuli as more threatening. A second limitation relates to the type of stimuli used. For example, previous work has indicated that using personalised stimuli in a group of social drinkers can increase alcohol-related attentional bias (Fridrici et al., 2013) and increase predictive validity for alcohol involvement (Christiansen & Bloor, 2014). It would therefore be interesting to see if the effects of alcohol cues reported here could be larger for personalised stimuli.

In summary this research illustrates the important role played by reactive and proactive cognitive control mechanisms in drinkers. In particular it highlights the flexible nature with which executive functions can control automatic processes in heavy and light drinkers.

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Table 1: Age (in years) and Audit scores for heavy and light drinkers.

	Heavy drinkers			Light drinkers		
	Mean	SD	range	mean	SD	range
Age	19.51	1.44	18-23	20.44	3.72	18-37
AUDIT	13.77	4.82	8-30	4.76	2.11	1-7

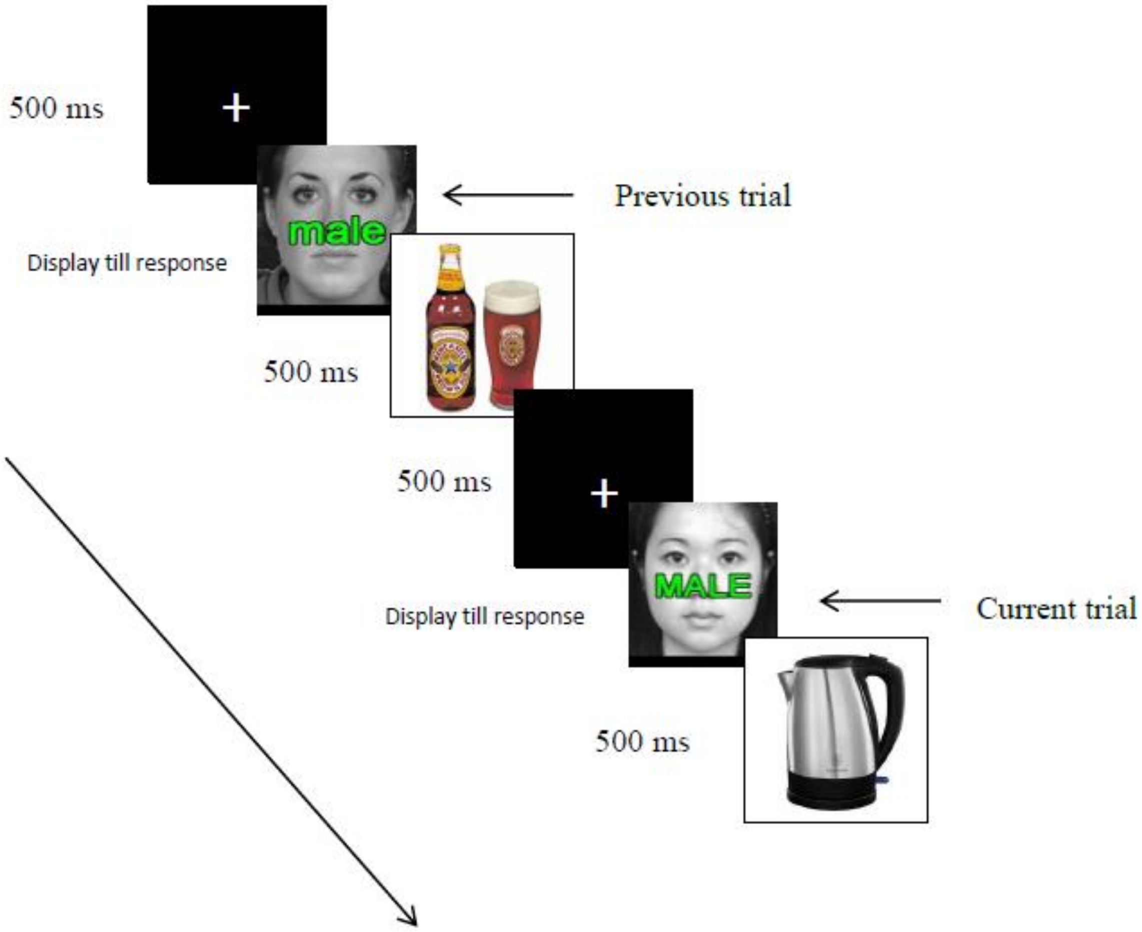
500 ms
+
Display till response
male
Previous trial
500 ms
500 ms
+
Display till response
MALE
Current trial
500 ms

Figure 1

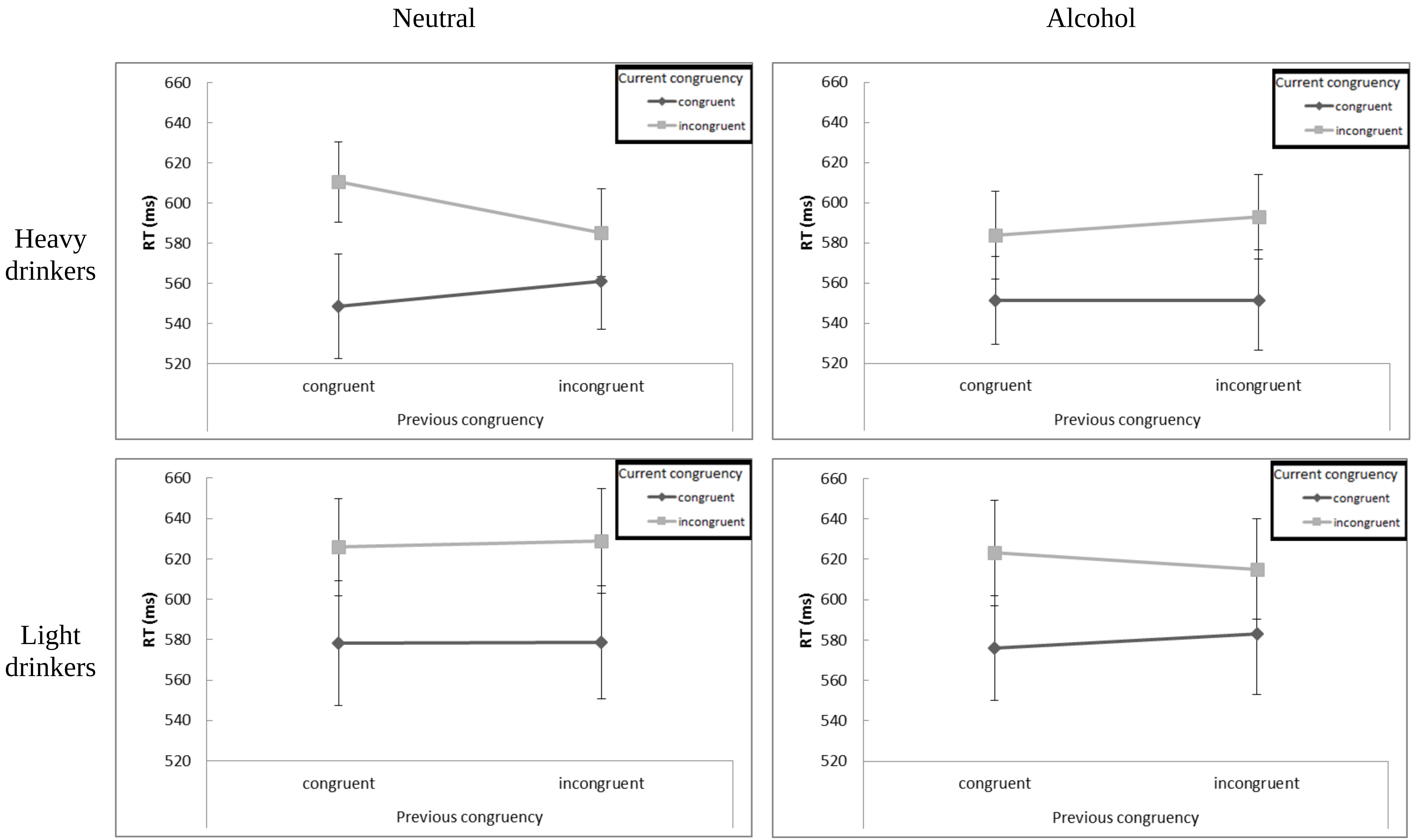
Neutral
Alcohol
Heavy drinkers
Light drinkers
Current congruency
congruent
incongruent
RT (ms)
660
640
620
600
580
560
540
520
congruent
incongruent
Previous congruency

Figure 2

Figure 1. Shows two trials, an incongruent trial followed by an incongruent trial, with an alcohol image between them.

Figure 2. Shows the response latencies for all conditions to illustrate conflict adaptation (previous x current congruency) changes with Group (heavy, light drinkers) and previous image type (alcohol, neutral). Errors bars show ±1 standard error.

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