Addictive Behaviors 39 (2014) 945–948

Contents lists available at ScienceDirect

Addictive Behaviors

Short Communication

Reward and punishment sensitivity and alcohol use: The moderating role of executive control

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HIGHLIGHTS

- Reward sensitivity was positively related to alcohol use.
- Punishment sensitivity (PS) was negatively related to alcohol use.
- Reward sensitivity was an independent predictor of alcohol use.
- Executive control moderated the relation between PS and alcohol use.

ARTICLE INFO

Available online 18 December 2013

Keywords:
Alcohol use
Reward sensitivity
Punishment sensitivity
Executive control

ABSTRACT

Reward sensitivity and to a lesser extent punishment sensitivity have been found to explain individual differences in alcohol use. Furthermore, many studies showed that addictive behaviors are characterized by impaired self-regulatory processes, and that individual differences related to alcohol use are moderated by executive control. This is the first study that explores the potential moderating role of executive control in the relation between reward and punishment sensitivity and alcohol use. Participants were 76 university students, selected on earlier given information about their alcohol use. Half of the participants indicated to drink little alcohol and half indicated to drink substantial amounts of alcohol. As expected, correlational analyses showed a positive relationship between reward sensitivity and alcohol use and a negative relation between punishment sensitivity and alcohol use. Regression analysis confirmed that reward sensitivity was a significant independent predictor of alcohol use. Executive control moderated the relation between punishment sensitivity and alcohol use, but not the relation between reward sensitivity and alcohol use. Only in individuals with weak executive control punishment sensitivity and alcohol use were negatively related. The results suggest that for individuals with weak executive control, punishment sensitivity might be a protective factor working against substantial alcohol use.

1. Introduction

Heavy alcohol use during college leads to a number of negative consequences and predicts the development of alcohol use disorders (Engs, Diebold, & Hanson, 1996; O'Neill, Parra, & Sher, 2001). It is thus important to further our understanding of the factors involved in college drinking. Although individual differences in reward sensitivity (RS), punishment sensitivity (PS), and executive control have been proposed to be associated with alcohol use (e.g., Bijttebier, Beck, Claes, & Vandereycken, 2009; Wiers et al., 2007), it remains unclear how these factors interact.

Both RS and PS arose from the reinforcement sensitivity theory of Gray (1970; 1982; Gray & McNaughton, 2000). RS is derived from activity of the Behavioral Activation System (BAS) which is thought to respond with approach behavior to rewarding stimuli, and PS is derived from activity of the Fight–Flight–Freeze system (FFFS) which is thought to respond with avoidance behavior to aversive stimuli. Thus, individuals who are highly reward sensitive are more prone to respond with approach behavior in situations that are associated with reward, and individuals who are highly punishment sensitive are more prone to respond with avoidance behavior in situations that are associated with punishment.

It has been proposed that individuals who are highly reward sensitive are more likely to develop associations between alcohol cues and reward, increasing the extent to which the cues activate appetitive motivation and subsequent consumption (Smith & Anderson, 2001). Research showed that RS is indeed positively related to alcohol–reward associations (Kabbani & Kambouropoulos, 2013; Palfai & Ostafin, 2003), and there is ample evidence that self-reported RS is positively related to alcohol use (Bijttebier et al., 2009).

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0306-4603/$ – see front matter
http://dx.doi.org/10.1016/j.addbeh.2013.12.011

Conversely, PS is negatively related to alcohol–reward associations (O'Connor & Colder, 2009; Simons, Dvorak, & Lau-Barraco, 2009), and individuals with high PS tend to use less alcohol than those with low PS (Bijttebier et al., 2009). Consistent with this, it has been found that among heavy drinking students who received an infraction for their alcohol use, those with stronger PS were more likely to reduce their drinking (Wray, Simons, & Dvorak, 2011). Thus both high RS and low PS may facilitate the development of alcohol misuse.

The inability to direct thought and action towards obtaining goals (weak executive control) has also been found to be associated with alcohol use (Miller & Wallis, 2009). Pointing to the relevance of weak executive control in substance abuse there is ample evidence that addictive behaviors are characterized by impaired self-regulatory processes (e.g., Bühringer et al., 2008). According to current dual-process models, excessive alcohol use results from an interplay of automatic processes and the reflective system. The reflective system depends on executive control that can inhibit these automatic processes (Deutsch & Strack, 2006, Wiers et al., 2007). In line with this model, it has been shown that the appetitive valence of alcoholic stimuli has a greater role in predicting alcohol use of individuals with weak compared to individuals with strong executive control (Van Hemel-Ruiter, de Jong, & Wiers, 2011). Since RS and PS have been found to relate to automatic processes (O'Connor & Colder, 2009; Palfai & Ostafin, 2003), the predictive value of RS and PS for alcohol use may be similarly tempered by executive control. This would mean that, when executive control is weak, the reflective system is unable to inhibit the automatic processes related to RS and PS.

The current study is the first to examine whether the relationship between RS and PS and alcohol use is indeed moderated by executive control. More specifically, this study tested whether (1) there is a positive relationship between RS and alcohol use, (2) there is a negative relationship between PS and alcohol use, and (3) the relationships between RS and PS and alcohol use are most pronounced in individuals with weak executive control.

2. Method

2.1. Participants

Participants were undergraduate students of the University of Groningen ($N = 78$) who were either light (between 1 and 9 alcoholic drinks a week) or heavy (over 16 alcoholic drinks a week) alcohol users. They were selected from a group of 250 students who completed a questionnaire on alcohol use and gave permission to be contacted for future research. During the study one participant reported no use of alcohol, and one participant had missing data on the Sensitivity to Punishment and Sensitivity to Reward Questionnaire, both were excluded. A total number of 76 participants (26 males, 50 females; average alcohol use = 15.5, $SD = 13.05$), aged 18–32 years, remained in the final analyses.

2.2. Material

2.2.1. Alcohol use

Alcohol use was measured with the Dutch alcohol use questionnaire (Wiers, Hoogeveen, Sergeant, & Gunning, 1997), based on the timeline follow-back method (Sobell & Sobell, 1990). Participants indicated their alcohol consumption during each day of the previous week. Alcohol consumption was transformed to standard Dutch servings (about 11 ml of pure alcohol). Alcohol use was calculated by summing the reported amount of alcoholic drinks consumed in the past week (Cronbach's alpha = 0.70).

2.2.2. Sensitivity to punishment and reward

RS and PS were measured with the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Ávila, Moltó, & Caseras, 2001; Franken & Muris, 2006b). The SPSRQ contains 24 questions about sensitivity to reward and 24 questions about sensitivity to punishment. Participants answer with either *yes* (1) or *no* (0). Scores can range from 0 to 24 with higher scores reflecting higher sensitivity to either reward or punishment.[1] Reliability values of the RS and PS subscales in the current study were average to good (Cronbach's alpha was 0.70 and 0.78, respectively).

2.2.3. Executive control

Executive control was measured with the attentional network task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002). During this computer task, participants have to determine whether a central arrow, that may or may not be accompanied by flankers (congruent or incongruent), points to the left or right. The arrow appears either above or below a fixation point shown in the middle of the screen. There are trials without a cue (no cue), trials in which a cue signals that the target is coming (center or double cue) and trials in which the cue signals that the target is coming and where (up or down) the target is coming (spatial cue). Executive control is calculated by subtracting the average mean reaction time of congruent flanking conditions from that of incongruent flanking conditions. Lower scores represent better executive attention.

The task consisted of 24 practice trials, 2 buffer trials, and 288 experimental trials. During the experimental trials all combinations of flanker type (none, congruent, incongruent), cue condition (no cue, center cue, double cue, spatial cue) and position (left or right and up or down) were presented six times.

2.3. Procedure

Approval for the study was provided by the Institutional Review Board of Psychology of the University of Groningen. Participants signed informed consent after receiving the pertinent information. Participants started with the ANT and subsequently completed the alcohol use questionnaire and the SPSRQ. Participants received study credits for their participation.

2.4. Analyses

Two hierarchical regression analyses were performed with alcohol use as dependent variable. In the first step RS, PS, and executive control were entered. In the second step the interaction between RS and executive control (model A), or the interaction between PS and executive control (model B) was entered. The independent variables were centered before being entered in the models.

3. Results and discussion

The major results can be summarized as follows: (1) RS was positively ($r = 0.34$, $p < 0.01$), and PS negatively ($r = -0.27$, $p = 0.02$), related to alcohol use; (2) RS showed independent predictive validity for alcohol use; and (3) executive control had a moderating role in the negative relationship between PS and alcohol use (see Table 1).

Replicating previous research (Bijttebier et al., 2009), the present study found a direct relationship between RS and alcohol use. Individuals who scored one point higher on the RS subscale reported on average to drink almost 1 alcoholic drink per week more (95% CI = [0.32; 1.81]). When RS was included in the model, PS was no longer a significant predictor of alcohol use. This again is in line with previous studies,

[1] The analyses were also performed after calculating the SPSRQ scales as proposed by O'Connor, Colder and Hawk (2004). However, since the outcomes of these analyses were similar to the analyses with the original scales they were not reported. An additional advantage of this reanalysis is that the question "Do you like to take some drugs because of the pleasure you get from them" was no longer included in the RS subscale. This makes it more plausible that the SPSRQ really measures general RS.