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The Association between Reward Sensitivity and Activity Engagement: the Influence of Delay Discounting and Anhedonia

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Abstract

Aim: Reward sensitivity affects individuals' motivation to engage in goal-directed behavior. Other concepts, critical for reward appraisal, that potentially influence activity participation encompass delay discounting and anhedonia. The aim of this study was to test the hypothesis that anhedonia and delay discounting influence the relationship between reward sensitivity and activity engagement.

Methods: In total, 37 inpatient patients with an alcohol use disorder (AUD) and 37 matched healthy controls completed the behavioral activation system scale (BAS scale), the Pleasant Activities List (PAL), the Snaith–Hamilton Pleasure Scale (SHAPS) and the Delay Discounting Task (DDT).

Results: Patients differed from controls on SHAPS, DDT-*k*, PAL substance-related activities (SRA), but not BAS and PAL non-substance-related activities (non-SRA). Correlational analyses revealed a strong correlation between BAS and PAL non-SRA in both patients ($r = 0.53$) and controls ($r = 0.47$), but also with PAL-SRA in patients ($r = 0.40$), although not controls ($r = 0.09$). BAS was negatively correlated with SHAPS in both groups and with DDT in controls. SHAPS was negatively linked to PAL non-SRA in both groups. The BAS-PAL non-SRA relationship was influenced by discount rates in controls.

Conclusion: A strong link exists between reward sensitivity and engagement in non-SRA in both groups. Delay discounting affects the reward sensitivity and non-SRA association in healthy controls, while anhedonia did not impact the association between reward sensitivity and engagement in (non-)SRA in both conditions.

INTRODUCTION

Addiction is currently considered a primary chronic disease of brain reward, motivation, memory and related circuitry (American Society of Addiction Medicine, 2014). As shown in a study of Welsh *et al.* (1993) in patients residing in an inpatient substance treatment unit and non-alcoholics in a general medical setting, individuals with an alcohol use disorder (AUD) function more poorly than those without an AUD. Moreover, they report more negative life events and experience more chronic stressors compared to non-problem drinking individuals of elderly age (Brennan and Moos, 1991). Those with an AUD tend to engage less in non-drinking activities such as sport and hobbies (Miller *et al.*, 1999) when compared to healthy

controls. In general, problematic substance use is associated with a low density of multiple types of substance-free reinforcement (Van Etten *et al*., 1998; Roozen *et al*., 2008).

The promotion of alternative pleasant activity engagement has become increasingly clinically important as part of behavioral addiction treatment (Meyers and Smith, 1995; Petry *et al*., 2000; Higgins *et al*., 2004). Understanding individual differences in behavioral and affective responses to healthy activity engagement, as a source of alternative reinforcement to compete with problematic alcohol use, is essential for the development of novel interventions (e.g. Rhodes and Smith 2006). From a Behavioral Choice Theory perspective (Vuchinich and Tucker, 1983, 1988), the reinforcing valence of substances is a contextually determined product of the direct reinforcing effects of the drug, individual factors such as maladaptive impulsivity (e.g. delay discounting), sensitivity to rewards, and the availability of alternative competing reinforcers (Bickel and Marsch, 2001). From a theoretical point of view and research conducted in pre-clinical (Solinas *et al*., 2008), non-clinical (Correia *et al*., 2005) and clinical samples (Etten *et al*., 1998; Roozen *et al*., 2008), a pleasant non-substance-related activity increase is negatively associated with substance use.

Multiple personality traits, such as extraversion (Eysenck, 1967), sensation-seeking (Zuckerman, 1993) and functional impulsivity, which is defined as the tendency to act with relatively little forethought when such a style is optimal and beneficial (Dickman, 1990), may predispose individuals to activity engagement through a reinforcement sensitivity mechanism (Smillie and Jackson, 2006). For example, extraversion (i.e. the tendency to be sociable, assertive, seek excitement and experience positive affect) proved to be the most prominent predictor of (physical) activity engagement (Rhodes and Smith, 2006; Roozen *et al*., 2014). Extraversion reflects the 'approach' component of a dual model of personality that divides motivation and behavior into two types of action tendencies: approach and avoidance (Carver *et al*., 2000). Two basic neurobehavioral systems have been described to control the approach and withdrawal tendencies: the behavioral activation system (BAS) and the BIS (Gray, 1970, 1987; Carver *et al*., 2000; Franken *et al*., 2006). The BIS is activated by punishment, omission/termination of reward and novelty (Gray, 1993), whereby individuals with a high BIS sensitivity tend to be sensitive to cues linked to punishment, and they inhibit behavior that leads to negative outcomes (Carver and White, 1994). Conversely, a study investigating undergraduate students showed that individuals with a high BAS sensitivity tend to be more sensitive to cues associated with reward and tend to engage more in goal-directed behavior (Carver and White, 1994). However, the value of BAS for understanding health-related behaviors, such as the promotion of prosocial activity engagement, in the treatment of AUD, has been relatively understudied. Nevertheless, it has been documented that BAS is positively linked with facets of pleasant activity engagement in patients with various substance use disorders (Strietman, 2006). Since reward sensitivity is linked with the mesolimbic dopaminergic circuits under young adult heavy drinkers in the general population (Kambouropoulos and Staiger, 2001), and dopamine with positive affect and approach behavior (Arias-Carrión and Pöppel, 2007), reward sensitive individuals may have less efficient inhibitory dopaminergic synapses on striatal neurons associated with decreased dopamine release. Due to a lower hedonic tone, these individuals seem to be more sensitive to dopamine activation, and it makes them focus on reward cues when compared to individuals having a higher hedonic tone (Dawe *et al*., 2007).

Due to neurobiological adaptations of long-term substance use, the engagement in healthy activities may be affected in AUD patients, characterized by a decreased sensitivity to natural reward and increased sensitivity to compulsive alcohol and drug-seeking behavior (Spanagel and Weiss, 1999; Cohen *et al*., 2005). A characteristic of such a dysfunctional reward system is the systematic discounting of delayed non-substance-related rewards (Kirby *et al*., 1999; Bickel and Marsch, 2001; Schmaal *et al*., 2012), which is considered to be one of the behavioral decision-making deficits (Monterosso *et al*., 2001). It is associated with under-engagement in healthy alternatives to drinking because of the benefits of these alternative activities are generally delayed (Murphy *et al*., 2012) and may not be considered as enjoyable at the moment (Murphy *et al*., 2006). Patients with an AUD will prefer an immediate reward over a future reward, even if the future reward has more clear advantages than an immediate reward. Discounting the value of delayed rewards (i.e. higher discount rates) is associated with impulsive choices that are focused on immediate gratification (e.g. substance-using behavior) and encumber the ability to work toward long-term goals (Kirby *et al*., 1999; Bickel and Marsch, 2001; Reynolds, 2006). Moreover, sensitivity for reward cues (i.e. BAS) predicts the behavioral decision-making deficits (Franken and Muris, 2005). Individuals with high reward sensitivity tend to make more rational choices regarding smaller but more consistent gains.

Anhedonia (i.e. the inability to experience pleasure from activities usually found enjoyable; Ribot, 1896), is another indication of neurobiological disruptions in the dopaminergic system (Hatzigiakoumis *et al*., 2011). This complex phenomenon consists of affective, cognitive, and behavioral components (Snaith, 1993). Anhedonia refers both to a state symptom and to a personality trait (Loas and Pierson, 1989). It is shown to be a frequent symptom in patients with an AUD (Heinz *et al*., 1994; Franken *et al*., 2006) and it plays a critical role in relapse in substance use (Koob and Le Moal, 2001; Volkow *et al*., 2002). There is a link with a dysfunction of the dopaminergic reward system as observed in pre-clinical (Diana *et al*., 1996; Willner, 1997) and clinical samples (Markou and Koob, 1991; Heinz *et al*., 1994). Moreover, it is associated with diminished reward responsivity (i.e. BAS) and reduced motivation to seek out rewarding stimuli in a non-clinical sample (Germans and Kring, 2000). Furthermore, anhedonia has been negatively linked to activity engagement (Leventhal, 2012), and to delay discounting rate in healthy individuals, suggesting that anhedonic individuals are inclined to choose a more substantial delayed reward upon a low immediate reward (Lempert and Pizzagalli, 2010).

The purpose of this study was to investigate the association between BAS personality trait and substance-related activities (SRAs)/non-substance-related activities (non-SRAs) in both AUD patients and healthy controls. This will contribute to a better understanding of the role of individual differences in behavioral and affective responses related to engagement in healthy activities, which is typically promoted in evidence-based addiction treatment, such as the Community Reinforcement Approach (Meyers and Smith, 1995). Impulsivity has been defined as 'a trait-like proclivity to engage in impulsive behaviors, either due to unusually strong impulses or to difficulty with reasoning about or controlling impulsive actions' (Jentsch *et al*., 2014, p. 3). Since it has been observed that impulsivity is positively related to delay discounting (Kirby *et al*., 1999) and negatively related to anhedonia (Germans and Kring, 2000), the second objective of this study was to examine the differential effect of delay discounting and anhedonia on this aforementioned

BAS-SRAs/non-SRAs association by performing correlational analyses. It was expected that both delay discounting and anhedonia influence the BAS-non-SRAs relationship negatively, while delay discounting and anhedonia would positively impact the BAS-SRA relationship.

METHOD

Participants

After the application of the in- and exclusion criteria, the final sample in the current study consisted of 37 patients with an AUD and 37 matched healthy controls. All of these participants were included in the analyzes. The patients were diagnosed according to the guidelines of the DSM-IV (American Psychiatric Association, 2000). Medical doctors, psychiatrists, and psychologists conducted the assessment substance use applying a clinical interview. Criteria for inclusion in the patient group were as follows: an AUD diagnosis, age between 24 and 65 years, and a minimum score of 25 on the Mini-Mental State Examination (MMSE; Folstein *et al*., 1975). The MMSE was employed for examination of cognitive functioning in order to increase the validity of the test instruments. As research has shown, the cut-off score of 25 points reflects adequate cognitive functioning under individuals treated in mental health centers (Mackin *et al*., 2010). The exclusion criteria for patients contained withdrawal symptoms. Patients that resided in the treatment center for <7 days and had a high likelihood of experiencing withdrawal symptoms due to recent use of alcohol were not included in the present study.

Using a matched-control design (case-matched for age, gender and education level), the group of healthy controls was recruited from similar community settings (Noord-Brabant) via word-of-mouth referrals. All participants completed the Alcohol Use Disorders Identification Test (AUDIT) (Saunders *et al*., 1993). Since the previous research showed different optimal cut off scores of AUDIT for men and women (Reinert and Allen, 2002; Cherpitel *et al*., 2005; Aalto *et al*., 2006), separate AUDIT scores were used to identify an AUD among men and women. An AUDIT score lower than 8 (men) or 6 (woman) was required for inclusion within the control group. The non-response rate for patients was 12.2% and controls 9.2% due to time and motivational constraints. Thirteen controls were excluded from the present study because of AUDIT scores ≥ 8. No participants were excluded because of low MMSE scores. Of the total sample ($n = 74$), >78% completed the questionnaire without any missing values. Almost 14% had one to ten missing values in the assessment battery. In total, 8% had ~20 missing values across all of the questionnaires administered.

The socio-demographic characteristics of both samples are summarized in Table 1. No statistically significant differences emerged between patients and the control group with respect to the matching variables. However, statistically significant differences were found on marital status ($\chi^2 = 34.06$, $P < 0.001$), housing ($\chi^2 = 30.77$, $P < 0.001$), and employment ($\chi^2 = 20.33$, $P < 0.001$). As expected, the patient group reported a higher frequency of alcohol use ($\chi^2 = 42.44$, $P < 0.006$) and used significantly more alcohol in the past 30 days than controls [t (53.39) = −11.06, $P < 0.001$]. More than 86% of the patients and 2.7% of the controls used alcohol at least four times a week. In total, 32% of the patients and 3% of the controls additionally used illegal drugs in the past 30 days [t (36.94) = −3.52, $P = 0.001$]. More than 13% of the patients used alcohol as well as drugs such as cannabis and cocaine (homotypic comorbidity).

Procedure

All eligible participants filled in written informed consent prior to participation. After an explanation of the rationale and procedure, all patients were assessed using interviews (e.g. socio-demographic and substance use-related information) and self-reports by a team of independent researchers. During the assessment, all patients resided in an inpatient treatment center for at least 7 days ($M = 22.77$, SD = 22.87, range: 7–90) with a minimal of 7 days of abstinence ($M = 22.19$, SD = 23.64, range: 7–100). Patients' medication dosage regimen was based on a national applied protocol (De Jong *et al*., 2004) by generally using chlordiazepoxide with an average dose of 40–200 mg q.i.d. or diazepam with an average dose of 20–80 mg q.i.d. As such, the dosage regime was frequently tapered within a 7-day period, based on staff observations and patients' self-reported symptoms. In general, after this period of time most of the withdrawal symptoms subsided. This study was approved by the local ethics committee (Tilburg University).

Instruments

BIS/BAS Scale The Behavioral Inhibition System (BIS)/BAS Scale is a self-report questionnaire that measures the individual sensitivity of the appetitive and aversive motivational system (Carver and White, 1994). Only the BAS activation was assessed in this study by the Dutch translation of Carver and White's (1994) BIS/BAS scales (Franken *et al*., 2005). The BAS scale consists of three subscales: fun seeking (four items), reward responsiveness (five items) and drive (four items), that were merged into one BAS-scale. This because of a higher internal consistency of the newly composed BAS-scale found in previous studies (Gomez and Gomez, 2002; Quilty and Oakman, 2004). Moreover, the original BAS subscales strongly load on a second order BAS factor (Jorm *et al*., 1999; Van der Linden *et al*., 2007; Yu *et al*., 2011). All items, such as 'I go out of my way to get the things I want.', were measured on a four-point Likert scale varying from 'totally agree'(1) to 'totally disagree'(4). Higher values represent higher levels of BAS activation. Cronbach's alpha of the total BAS score in this study was 0.85.

The Snaith–Hamilton Pleasure Scale The SHAPS is a validated 14-item scale, which measures the level of anhedonia (Franken *et al*., 2007). Items of the Snaith–Hamilton Pleasure Scale (SHAPS) are assessed on a five-point Likert scale varying from 'totally agree'(1) to 'totally disagree'(5). All participants rated how strongly they would enjoy various experiences that are generally considered pleasurable, for example, 'I can enjoy reading a book, magazine or newspaper.' Higher values represent higher levels of anhedonia. Cronbach's alpha of the total SHAPS score in this study was 0.91.

Delay Discounting Task A computerized Delay Discounting Task (DDT, Richards *et al*., 1999) was used to study impulsive choice behavior. These impulsive choices relate to impulsive decisions resulting from a distorted evaluation of delayed behavioral consequences and an increased preference for immediate rewards over beneficial delayed rewards (Broos *et al*., 2012). Participants had to answer 138 questions asking to make a choice between a smaller amount of money receiving immediately or a larger amount of the money receiving later after 7, 30, 90, 180 or 365 days. Time to choose was unlimited. For each delay period, a participant's indifference point was calculated, which reflects a point at which the participant chose a smaller immediate value instead of a larger delayed value. According

Table 1. Sociodemographic characteristic

		Patients (N = 37)	Controls (N = 37)	Group differences
Age (years)		47.6 (SD = 9.4)	46.5 (SD = 10.1)	t (82) = −0.52
Gender (%)	Male	73.0	75.7	χ^2 = 0.071
	Female	27.0	24.3	
Ethnicity (%)	European	100.0	100.0	
Marital status (%)	Single	51.4	5.4	χ^2 = 34.06***
	Married	18.9	81.1	
	Relationship	13.5	13.5	
	Divorced	10.8	0.0	
	Widow(er)	5.4	0.0	
Housing (%)	Single	54.1	8.1	χ^2 = 30.76***
	With partner	16.2	37.8	
	With partner and children	13.5	54.1	
	Single with children	5.4	0.0	
	With parents	0.0	0.0	
	Other	10.8	0.0	
Education (%)	None	10.8	2.7	χ^2 = 2.16
	Lower	18.9	21.6	
	Secondary	51.4	59.5	
	Higher	18.9	16.2	
Employment (%)	Full-time	35.1	78.4	χ^2 = 20.33***
	Part-time	18.9	18.9	
	Unemployed	43.2	2.7	
	Other	2.7	0.0	

Note: Significant group differences indicated by $^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

to Richards *et al*., (1999) delay discounting of a reward value is described by a hyperbolic discount function:

$$V = A/(1 + kD).$$

Factor V represents the indifference point, A represents the amount of the reward, the number 1 prevents the present value from approaching infinity as the delay approaches 0, and D represents the delay to the reward. The factor k represents a degree of discounting; it describes how steeply a value is degraded by delay (Odum, 2011). It is set by the fit of the model to the data (Odum, 2011). A higher discounting rate (i.e. a higher k-value) presents more likely a choice of an immediate smaller reward over a larger delayed reward.

Pleasant Activities List The Pleasant Activities List (PAL, Roozen *et al*., 2008) consists of 139 items and measures two parameters of reinforcement engagement during the previous 30 days: frequency (i.e. the amount of time engaged in the activity) and enjoyability (i.e. subjective enjoyment of the experience). Both are scored on a double five-point Likert scale varying from 'not at all'(1) to 'very often'(5). Consistent with the work of Correia *et al*. (1998) an adaptation was made to distinguish between alcohol-related and non-alcohol-related events. Consequently, each item was presented twice to measure PAL SRA/non-SRA in terms of frequency and enjoyability. Since patients with AUDs frequently suffer from homotypic comorbidity (i.e. illicit drug use) as well (Falk *et al*., 2008), the type of activities was expanded and rephrased to capture SRAs more generally. For example, participants rated (a) how often they go to a bar or cafe while sober and how enjoyable they experience that (non-SRA), and (b) how often they go to a bar or café while drinking alcohol or using drugs and how they enjoy this experience (SRA). The PAL SRA/non-SRA items were multiplied (frequency × enjoyability) separately for each item to calculate double cross-product scores: the PAL SRA cross-product and PAL non-SRA cross-product, as estimates of the total reported pleasure (Grosscup and Lewinsohn, 1980). Finally, based on Herrnstein's law (1970), a reinforcement ratio (RR) was calculated that represents the proportion of reinforcement derived from PAL SRA/non-SRA cross-product relative to total reinforcement obtained over the 30-day time-window. For each participant, the PAL SRA was divided by the sum of both PAL SRA and PAL non-SRA. The PAL RR ranges from 0 to 1, with a higher ratio indicative of a greater proportion of substance-related reinforcement relative to total reinforcement. The Cronbach's alphas were between 0.96 (PAL non-SRA frequency) and 0.99 (PAL SRA cross-product).

Statistical analyses

Little's chi-square statistic indicated that all missing values were missing at random ($P > 0.05$). Missing data were replaced through Missing Value Analysis (MVA), using the Expectation Maximization (EM) imputation algorithm. The imputations were applied separately for each scale. Imputed values were generated if patients have provided valid data for > 75% of the scale items. To normalize the k values (DDT), a $\log_{10}$ transformation was used. Furthermore, t-tests were applied to test continuous variables and chi-square for categorical data. Pearson product-moment correlations were computed to examine the strengths of the associations among variables. Building upon the classical theory of Baron and Kenny (1986), mediational analyses based on nonparametric bootstrapping for standard errors, including bias-corrected and accelerated (BCa) 95% confidence intervals (CI) were performed (Preacher and Hayes, 2004, 2008) to examine whether anhedonia and DDT-k mediate the associations between BAS and PAL SRA/non-SRA cross-product in both separate samples (see Fig. 1). Anhedonia and DDT were included in the tested model together. Such analyses have been recommended for relatively small

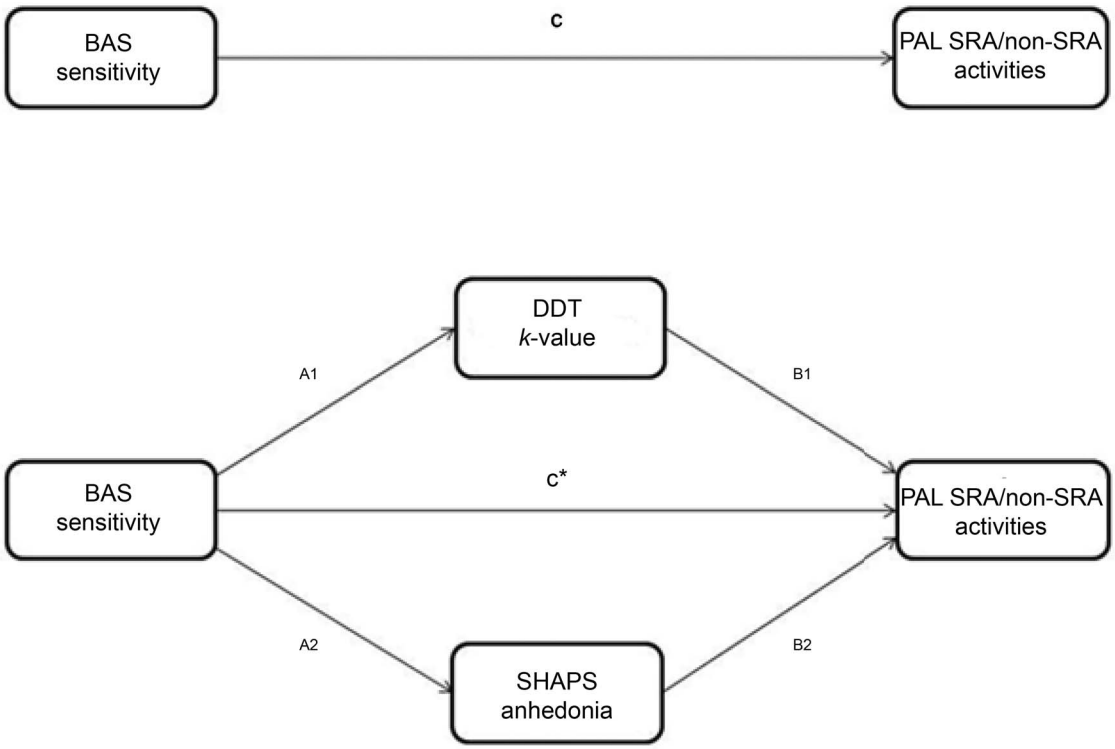

Fig. 1. Path model for multiple mediation analysis. In the upper panel of this figure, the patch coefficient denoted C represents the total relationship between BAS sensitivity and PAL substance/non-SRA engagement (SRA/non-SRA), not controlling for DDT-*k* values and SHAPS anhedonia. The lower panel of this figure illustrates the hypothesized causal model. The path denoted A represents the conditional effect of BAS impulsivity on DDT-*k* values/SHAPS anhedonia; the path denoted B represents the unconditional effect of DDT-*k* values/SHAPS anhedonia on PAL SRA/non-SRA. The strength of the mediated connection is found by multiplying A × B. The path denoted C′ represents the direct association between BAS sensitivity and PAL SRA/non-SRA, controlled for the mediated paths involving DDT-*k* values/SHAPS anhedonia.

samples, do not require distributional assumptions and have a quite low risk of inducing a Type I error. The indirect macro was employed to build a multiple mediational model. The bootstrap estimates were based on 5000 resamples ($z = 5000$). All *P*-values were two-sided and considered statistically significant at $P < 0.05$. All statistical analyses were performed using SPSS 20.0.

RESULTS

Group effects

Patients reported statistically significantly higher scores than controls in terms of all three PAL SRA scores: frequency [t (58.94) = −6.36, $P < 0.001$], enjoyability [t (72) = −5.20, $P < 0.001$] and PAL cross-product. Furthermore, similar findings were obtained regarding PAL RR (see Table 2 for an overview). Moreover, patients scored significantly higher than controls on DDT-*k* and SHAPS (see Fig. 2). No statistically significant group differences were found on BAS and all three PAL non-SRA scores: frequency, enjoyability, and cross-product.

Pearson product-moment correlations: subgroup analyses

In both patients and controls, BAS was positively associated with PAL non-SRA cross-product (see Table 3). Albeit somewhat weaker, BAS was also positively related to PAL SRA cross-product in the patient group. Only low and non-meaningful correlates emerged between DDT-*k* and PAL scores in both groups. Moreover, the correlation between SHAPS and PAL SRA cross-product and PAL RR did not reach statistical significance in both samples. The link between SHAPS and PAL non-SRA was negative and statistically significant in both groups. BAS was negatively correlated with DDT-*k* in the control group and with SHAPS in both patients and controls. DDT-*k* was positively correlated to SHAPS in the patient group only.

Mediational model: subgroup analyses

Table 4 displays the mediational indices of both subgroups. In the patient sample, statistically significant total effects were shown between BAS and PAL SRA/non-SRA cross-product, except for PAL RR (C = −0.3, $P > 0.05$). Indirect effects through DDT-*k* and SHAPS between BAS and PAL SRA/non-SRA cross-product scores did not reach statistical significance. In the control sample, a statistically significant total effect emerged between BAS and PAL non-SRA cross-product. The DDT-*k* partially mediated this relationship (A1 × B1 = −4.45, BCa95% CI = −12.90 to −0.42) and acted as a suppressor variable, since the value representing the magnitude of the relationship between BAS and PAL non-SRA increased while DDT-*k* was included. Subsequently, additional analyses were conducted with only single mediators showing that the increase of the direct effect with respect to the total effect was caused by DDT-*k* (C = 14.83, $P < 0.01$; C′ = 19.47′ $P < 0.001$) and not by SHAPS (C = 15.82, $P < 0.01$; C′ = 13.16′ $P < 0.05$).

DISCUSSION

The aim of this study was to investigate the relationship between BAS and PAL SRA/non-SRA in patients with AUD and healthy

Table 2. Group differences

	Patients	(N = 37)	Controls	(N = 37)	t (df)
	M	SD	M	SD	
BAS sensitivity	37.05	6.87	39.38	6.61	t (72) = 1.48
DDT k-value	−1.38	1.35	−2.54	0.94	t (58.69) = −4.15***
SHAPS anhedonia	28.68	8.76	22.32	7.85	t (58.94) = −3.29**
PAL SRA	730.62	419.84	291.62	209.12	t (72) = −5.69***
PAL non-SRA	907.11	460.07	769.34	222.48	t (51.96) = −1.64
PAL RR	0.45	0.12	0.26	0.11	t (72) = −6.75***

Note: Figures are means and standard deviations. PALSRA/non-SRA indices represent PAL cross-product scores. PAL RR is reinforcement ratio. Significant group differences indicated by $^{*}P < 0.05$,$^{**}P < 0.01$,$^{***}P < 0.001$.

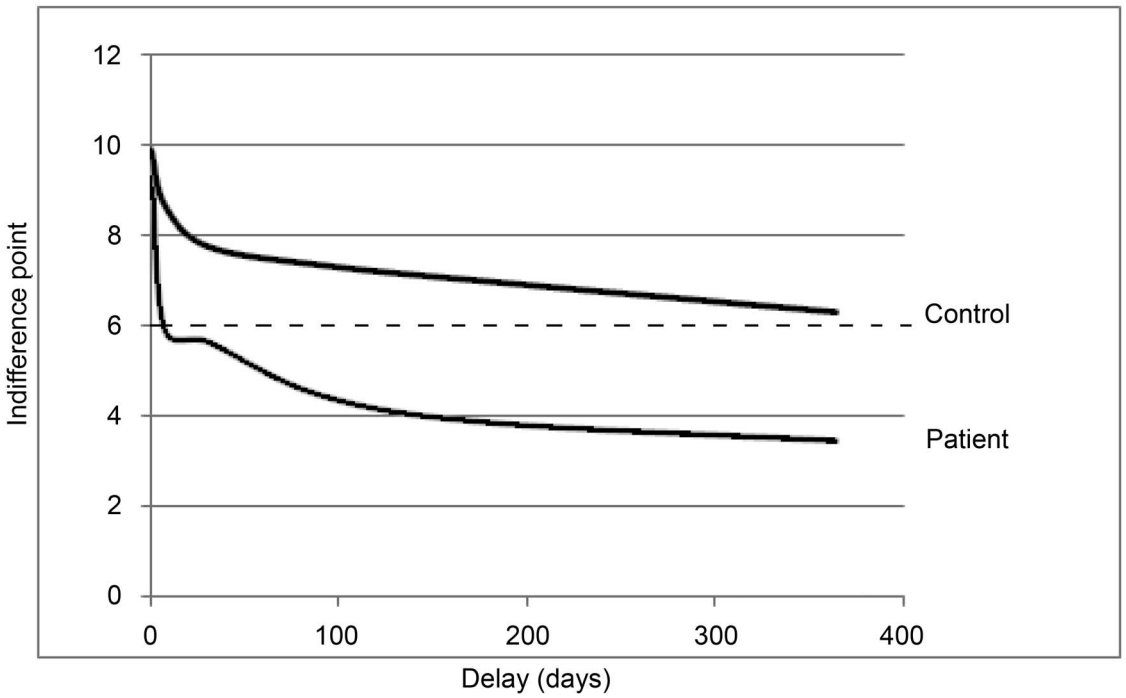

Fig. 2. Mean discounting function by patients and controls. The curves for both patients and controls are indifference points that represent points at which participants prefer a small immediate value instead of a higher delayed value for a given delay period as a function of delay. Group differences were statistically significant [F (1, 72) = 17.00, $P < 0.001$, partial eta squared = 0.19]. Range k values patient sample = 9.16, range k values control sample = 2.22.

Table 3. Univariate strength of correlations between measures

	1	2	3	4	5	6
1. BAS sensitivity	–	−0.30	−0.45*	0.40*	**0.53****	−0.13
2. DDT k-value	−0.34*	–	0.39*	0.05	−0.04	0.06
3. SHAPS anhedonia	−0.45**	0.08	–	−0.01	−0.43**	0.44**
4. PAL SRA	0.09	−0.07	0.13	–	**0.53****	0.48**
5. PAL non-SRA	0.47**	0.21	−0.35*	0.28	–	−0.44**
6. PAL RR	−0.20	−0.07	0.36*	**0.80****	−0.28	–

Note: Figures are Pearson product-moment correlations. Strong correlations (>0.50; Cohen, 1988, 1992) are presented in bold, very strong correlations (>0.70) are also underscored. The correlational values above the diagonal mirror represent the patient sample and those below the diagonal represent the control group. PALSRA/non-SRA indices represent PAL cross-product scores. PAL RR is reinforcement ratio. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

controls. DDT-k and SHAPS were included in correlational analyses, by using a mediational design, to examine their impact on this relationship. The main hypothesis of the current study assumed that both delay discounting and anhedonia would show a negative influence on the BAS-non-SRAs relationship, while delay discounting and anhedonia would show a positive impact on the BAS-SRA relationship. It emerged that patients with a higher level of BAS reward sensitivity engaged more in PAL non-SRA. Furthermore,

Table 4. Results of mediation analysis for BAS sensitivity as predictor of PAL SRA/non-SRA with paths to represent mediation by DDT *k*-values and SHAPS anhedonia

	Sample	Total effect BAS sensitivity	Direct effect BAS sensitivity	Mediation by DDT k-values			CI		Mediation by SHAPS anhedonia			CI		
		C	*C′*	A1	B1	A1 × B1	Lower	Upper	A2	B2	A2 × B2	Lower	Upper	R^2
PAL SRA	Controls	−0.94	1.07	−0.05*	−15.10	0.75	−1.60	7.64	−0.60**	4.59	−2.77	−10.07	1.07	0.03
	Patients	22.68**	29.77**	−0.06	37.63	−2.19	−14.20	2.81	−0.60**	8.15	−4.90	−13.05	5.41	0.26*
PAL non-SRA	Controls	14.83**	16.93**	−0.05*	89.54*	−4.45	**−12.90**	**−0.42**	−0.60**	−3.89	2.35	−3.15	8.86	0.35**
	Patients	35.80**	31.43**	−0.06	72.61	−4.22	−18.06	1.36	−0.60**	−14.27	8.59	−0.22	28.04	0.36**
PAL RR (x 100)	Controls	−0.54	−0.40	−0.05*	−2.03	0.1	−0.04	0.47	−0.60**	0.39	−0.23	−0.56	0.01	0.19
	Patients	−0.28	0.07	−0.06	−1.14	0.07	−0.07	0.41	−0.60**	0.68*	−0.41	**−0.94**	**−0.12**	0.22

Note: Displayed are the outcomes of the independent samples. PAL SRA/non-SRA indices represent cross-product scores. PAL RR is reinforcement ratio. Indices are unstandardized. The PAL RR was multiplied by factor 100 to obtain a percentage score. The confidence intervals not containing a zero are bold-font marked. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

individuals with higher DDT-*k* engaged in more PAL SRA, while higher levels of anhedonia were inversely related to PAL non-SRA. Moreover, anhedonic patients tended to prefer a small immediate reward above large delayed rewards. Besides, it was confirmed that BAS predicted PAL non-SRA. In the control sample, DDT-*k* partially influenced the relationship between BAS and PAL non-SRA cross-product score. These findings suggest that discount rates play a role in the relationship between reward sensitivity and engagement in non-SRAs in controls and partially confirm our hypothesis with respect to delay discounting. Anhedonia was not found to influence the BAS PAL-SRA/PAL non-SRA relationship in this present study.

Previous studies have shown a lower level of activity engagement among patients with AUDs compared to healthy individuals (Etten *et al*., 1998; Roozen *et al*., 2008). However, in the current study, no statistically significant differences were found between both groups in terms of PAL non-SRA. This dissimilarity could be related to the double scoring format that was used to measure separate PAL SRA and non-SRA levels, as opposed to studies that used a single scoring format. This possible source of bias regarding activity measures was no longer observed when RR scores were calculated. As mentioned previously, promoting healthy activity engagement has become a crucial aspect of behavioral addiction treatment to compete with SRAs (Rogers *et al*., 2008; Meyers *et al*., 2011; McKay, 2017; Delmée *et al*., 2018). However, it emerged that roughly similar rates of PAL non-SRA activity frequency and enjoyability scores were obtained in both groups. Analog to students, alcohol use among patients might also be associated with aspects of (social) benefits and partner intimacy, and may act as an important social facilitator (e.g. Epstein *et al*., 2008; Testa *et al*., 2019).

The present study corroborates with previous findings in terms of discount rates (Murphy *et al*., 2006) and anhedonia (Heinz *et al*., 1994; Franken *et al*., 2006) in AUD patients. That is, discount rates were positively linked with SRAs (Murphy *et al*., 2006), while previous work demonstrated that anhedonia was negatively associated with substance-free activities (Leventhal, 2012). However, our data did not support this latter association.

This current study has several methodological strengths. The matched-control design ruled out possible confounding effects of demographical variables (gender, age, nationality and education) on the results of this study. The missing data were managed by the use of the EM, which was applied separately for each scale (Schafer and Olsen, 1998). Moreover, to estimate direct and indirect effects of BAS sensitivity on different PAL activity scores with DDT discount rates and SHAPS anhedonia, the methodology of Preacher and Hayes (2004, 2008) was used, advocated to overcome possible violations of the assumption of a normal distribution of the scales.

Nevertheless, there are also some limitations that have to be addressed. First, the study sample was relatively small. As such, therefore it was not desirable to correct for a Type 1 error and add covariates such as gender or age. Second, because of cross-sectional design of the present study with relatively small sample size, it was not appropriate to test the bidirectionality of the associations or to draw conclusions with respect to causality. Hence, it cannot be ruled out that alternative explanations may be viable too (MacKinnon, 2008). Third, although a case-matched design has been used, the sample in both groups consisted mainly of males, which has to be taken into account when generalizing the current findings to other populations or diagnostic groups. It must be noted that patients were admitted to an inpatient alcohol-detoxification unit for at least one week. Such a time-frame is frequently sufficient to complete the medically assisted withdrawal. Although even the data collection took place after a mean number of 23 days, we cannot exactly rule out the impact of (protracted) withdrawal symptoms in influencing the scores on the assigned measures. A possible influence of withdrawal symptoms on the measurement of anhedonia in the current study cannot be excluded since it has been substantiated that a possible decrease of dopaminergic state due to long-term substance use has to be taken into account while using the findings regarding reward sensitivity within the clinical practice (Robinson and Berridge, 1993; Volkow *et al*., 1996, 2011). Moreover, this study positioned the delay discounting as a consequence of long-term substance use (Spanagel and Weiss, 1999; Cohen *et al*., 2005). However, it should be noted that delay discounting may act as a risk factor for substance use and may predict the likelihood to recover from substance use as well (Robles *et al*., 2011). Yet both hypothetical aspects or even a reciprocal effect seems plausible, though remain inconclusive due to the small sample size and cross-sectional design of this study.

The results suggest that those who report higher sensitivity to rewards is more inclined to engage in prosocial healthy activities. Only in the control sample, we found a result that discounting delayed values suppresses this association, but on the other hand, stimulates the engagement in non-SRAs as well. The control sample was characterized with general low alcohol consumption (AUDIT < 8) and therefore the level of SRAs was

low as well, especially compared to patients. Despite the typical negative connotation surrounding 'delay discounting' it seems that it may have a positive influence on non-substance-related pleasant activity engagement. Owing to the positive association between reward sensitivity and extraversion that has been substantiated in previous research (Franken and Muris, 2005), this study emphasizes the importance to assess information about patients' individual differences in terms of appetitive motivation or reward sensitivity related to prosocial activity engagement that could support therapists to promote a sufficient level of adequate reinforcement derived by alternative and more healthy behaviors (Roozen *et al*., 2014). To assist this formidable task, prescribed incentives can be employed contingent on a 'successive approximation' toward a desired healthy activity engagement to enhance the short-term reinforcement magnitude.

CONCLUSION

Reward sensitivity levels appear to be strongly linked to engagement in non-SRAs in both patients and controls. In addition, we found that delay discounting affects the relationship between reward sensitivity and engagement in non-SRAs only in the control group. Future studies should include larger sample sizes with an equal distribution of gender. This would increase the validity and generalization of the current findings.

DISCLOSURE OF INTEREST

The second author receives honoraria for providing CRA workshops at universities, mental health institutes, conferences, and local city governments. In addition, the author receives royalties from publishers for scientific books and chapters. The other authors report no conflicts of interest.

REFERENCES

Aalto M, Tuunanen M, Sillanaukee P *et al.* (2006) Effectiveness of structured questionnaires for screening heavy drinking in middle-aged women. *Alcohol Clin Exp Res* **30**:1884–8.

American Psychiatric Association (2000) *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn. Washington DCAmerican Psychiatric Association.

American Society of Addition Medicine (ASAN). (2014) *Definition of addition*. Retrieved November 1, 2014, from http://www.asam.org/for-the-public/definition-ofaddiction.

Arias-Carrión O, Pöppel E (2007) Dopamine, learning and reward-seeking behavior. *Acta Neurobiol Exp* **67**:481–8.

Baron RM, Kenny DA (1986) The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* **51**:1173–82.

Bickel W, Marsch L (2001) Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction* **96**:73–86.

Brennan PL, Moos RH (1991) Functioning, life context, and help-seeking among late-onset problem drinkers: Comparisons with nonproblem and early-onset problem drinkers. *Br J Addict* **86**:1139–50.

Broos N, Schmaal L, Wiskerke J *et al.* (2012) The relationship between impulsive choice and impulsive action: a cross-species translational study. *PLoS One* **7**:e35781.

Carver CS, Sutton SK, Scheier MF (2000) Action, emotion, and personality: emerging conceptual integration. *Pers Soc Psychol Bull* **26**:741–51.

Carver CS, White TL (1994) Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: the BIS/BAS scales. *J Pers Soc Psychol* **67**:319–33.

Cherpitel CJ, Ye Y, Moskalewicz J *et al.* (2005) Screening for alcohol problems in two emergency service samples in Poland: comparison of the RAPS4, CAGE and AUDIT. *Drug Alcohol Depend* **80**:201–7.

Cohen J (1988) *Statistical Power Analysis for the Behavioral Sciences*, 2nd edn. Hillsdale, NJErlbaum.

Cohen J (1992) A power primer. *Psychol Bull* **112**:155–9.

Cohen MX, Young J, Baek JM *et al.* (2005) Individual differences in extraversion and dopamine genetics predict neural reward responses. *Cogn Brain Res* **25**:851–61.

Correia CJ, Benson TA, Carey KB (2005) Decreased substance use following increases in alternative behaviors: a preliminary investigation. *Addict Behav* **30**:19–27.

Correia CJ, Simons J, Carey KB *et al.* (1998) Predicting drug use: application of behavioral theories of choice. *Addict Behav* **23**:705–9.

Dawe S, Loxton NJ, Gullo MJ *et al.* (2007) The role of impulsive personality traits in the initiation, development, and treatment of substance misuse problems. In Miller PM, Kavanagh DJ (eds). *Translation of Addictions Science into Practice*. Amsterdam, The NetherlandsPergamon, 321–40.

Delmée L, Roozen HG, Steenhuis I (2018) The engagement of non-substance-related pleasant activities is associated with decreased levels of alcohol consumption in university students. *Int J Ment Health Addiction* **16**: 1261–9.

Diana M, Pistis M, Muntoni A *et al.* (1996) Mesolimbic dopaminergic reduction outlasts ethanol withdrawal syndrome: Evidence of protracted abstinence. *Neuroscience* **71**:411–5.

Dickman SJ (1990) Functional and dysfunctional impulsivity: Personality and cognitive correlates. *J Pers Soc Psychol* **58**:95–102.

Epstein JA, Griffin KW, Botvinsaid GJ (2008) A social influence model of alcohol use for inner-city adolescents: Family drinking, perceived drinking norms, and perceived social benefits of drinking. *J Stud Alcohol Drugs* **69**:397–405.

Etten ML, Higgins ST, Budney AJ *et al.* (1998) Comparison of the frequency and enjoyability of pleasant events in cocaine abusers vs. non-abusers using a standardized behavioral inventory. *Addiction* **93**: 1669–80.

Eysenck HJ (1967) *The Biological Basis of Personality*. SpringfieldThomas.

Falk D, Yi H, Hiller-Sturmhöfel S (2008) An epidemiologic analysis of co-occurring alcohol and drug use and disorders findings from the National Epidemiologic Survey of Alcohol and Related Conditions (NESARC). *Alcohol Res Health* **31**:100–10.

Folstein MF, Folstein SE, McHugh PR (1975) Mini- mental state. A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* **12**:189–98.

Franken IHA, Muris P (2005) Individual differences in decision-making. *Personal Individ Differ* **39**:991–8.

Franken IHA, Muris P, Georgieva I (2006) Gray's model of personality and addiction. *Addict Behav* **31**:399–403.

Franken IHA, Muris P, Rassin E (2005) Psychometric properties of the Dutch BIS/BAS scales. *J Psychopathol Behav Assess* **27**:25–30.

Franken IHA, Rassin E, Muris P (2007) The assessment of anhedonia in clinical and non-clinical populations: further validation of the Snaith-Hamilton Pleasure Scale (SHAPS). *J Affect Disord* **99**:83–9.

Germans MK, Kring AM (2000) Hedonic deficit in anhedonia: support for the role of approach motivation. *Personal Individ Differ* **28**:659–72.

Gomez A, Gomez R (2002) Personality traits of the behavioral approach and inhibition systems: associations with processing of emotional stimuli. *Personal Individ Differ* **32**:1299–316.

Gray JA (1970) The psychophysiological basis of introversion-extraversion. *Behav Res Ther* **8**:249–66.

GRAY JA (1987) Perspectives on anxiety and impulsivity: a commentary. *J Res Pers* **21**:493–509.

Gray JA (1993) Framework for a taxonomy of psychiatric disorder. In Gozen S, Poll N, Sergeant JA (eds). *Emotions: Essays on Emotion Theory*. New JerseyLawrence Erlbaum, 29–59.

Grosscup SJ, Lewinsohn PM (1980) Unpleasant and pleasant events, and mood. *J Clin Psychol* **36**:252–9.

Guyon A, Assouly-Besse F, Biala G *et al.* (1993) Potentiation by low doses of selected neuroleptics of food-induced conditioned place preference in rats. *Psychopharmacology (Berl)* **110**:460–6.

Hatzigiakoumis DS, Martinotti G, Di Giannantonio M *et al.* (2011) Anhedonia and substance dependence: clinical correlates and treatment options. *Front Psych* **2**:10.

Heinz A, Schmidt LG, Reischies FM (1994) Anhedonia in schizophrenic, depressed, or alcohol dependent patients: neurobiological correlates. *Pharmacopsychiatry* **27**:7–10.

Higgins ST, Heil SH, Lussier JP (2004) Clinical implications of reinforcement as a determinant of substance use disorders. *Annu Rev Psychol* **55**:431–61.

Holm S (1979) A simple sequential rejective multiple test procedure. *Scand J Stat* **6**:65–70.

Jentsch JD, Ashenhurst JR, Cervantes MC *et al.* (2014) Dissecting impulsivity and its relationships to drug addictions. *Ann N Y Acad Sci* **1327**:1–26.

Jong CAJ, AFM H, Jongerhuis M (2004) *Richtlijn Detox. Verantwoord Ontgiften Door Ambulante of Intramurale Detoxificatie*. AmersfoortGGZ Nederland - Resultaten Scoren, [Dutch].

Jorm AF, Christensen H, Henderson AS *et al.* (1999) *Using the BIS/BAS scales to measure behavioral inhibition and behavioral activation: Factor structure, validity and norms in a large community sample. Personal Individ Differ* 26:49–58.

Kambouropoulos N, Staiger PK (2001) The influence of sensitivity to reward on reactivity to alcohol- related cues. *Addiction* **96**:1175–85.

Kirby K, Petry N, Bickel W (1999) Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *J Exp Psychol Gen* **128**:78–87.

Koob GF, Le M (2001) Drug addiction, dysregulation of reward, and allostasis. *Neuropsychopharmacology* **24**:97–129.

Lempert KM, Pizzagalli DA (2010) Delay discounting and future-directed thinking in anhedonic individuals. *J Behav Ther Exp Psychiatry* **41**: 258–64.

Leventhal AM (2012) Relations between anhedonia and physical activity. *Am J Health Behav* **36**:860–72.

Loas G, Pierson A (1989) L'Anhédonie en psychiatrie: revue. *Ann Med Psychol* **147**:705–17.

Mackin RS, Ayalon L, Feliciano L *et al.* (2010) The sensitivity and specificity of cognitive screening instruments to detect cognitive impairment in older adults with severe psychiatric illness. *J Geriatr Psychiatry Neurol* **23**:94–9.

MacKinnon DP (2008) *Introduction to Statistical Mediation Analysis*. Mahwah, NJErlbaum.

Markou A, Koob GF (1991) Postcocaine anhedonia. An animal model of cocaine withdrawal. *Neuropsychopharmacology* **4**:17–26.

McKay JR (2017) Making the hard work of recovery more attractive for those with substance use disorders. *Addiction* **112**:751–7.

Meyers RJ, Roozen HG, Smith JE (2011) The community reinforcement approach: An update of the evidence. *Alcohol Res Health* **33**:380–8.

Meyers RJ, Smith JE (1995) *Clinical Guide to Alcohol Treatment: The Community Reinforcement Approach*. New YorkGuilford Press.

Miller WR, Meyers RJ, Hiller-Sturmhofel S (1999) The community reinforcement approach. *Alcohol Res Health* **23**:116–21.

Monterosso J, Ehrman R, Napier KL *et al.* (2001) Three decision-making tasks in cocaine-dependent patients: do they measure the same construct? *Addiction* **96**:1825–37.

Murphy JG, Barnett NP, Colby SM (2006) Alcohol-related and alcohol-free activity participation and enjoyment among college students: A behavioral theories of choice analysis. *Exp Clin Psychopharmacol* **14**:339–49.

Murphy JG, Skidmore JR, Dennhardt AA *et al.* (2012) A behavioral economic supplement to brief motivational interventions for college drinking. *Addict Res Theory* **20**:456–65.

Odum AL (2011) Delay discounting: I'm a k, you're a k. *J Exp Anal Behav* **96**:427–39.

Petry NM, Martin B, Cooney JL *et al.* (2000) Give them prizes, and they will come: contingency management for treatment of alcohol dependence. *J Consult Clin Psychol* **68**:250–7.

Preacher KJ, Hayes AF (2004) SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behav Res Meth Ins C* **36**:717–31.

Preacher KJ, Hayes AF (2008) Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav Res Methods* **40**:879–91.

Quilty LC, Oakman JM (2004) The assessment of behavioral activation – the relationship between impulsivity and behavioral activation. *Personal Individ Differ* **37**:429–42.

Reinert DF, Allen JP (2002) The alcohol use disorders identification test (AUDIT): a review of recent research. *Alcohol Clin Exp Res* **26**: 272–9.

Reynolds B (2006) A review of delay-discounting research with humans: relations to drug use and gambling. *Behav Pharmacol* **17**:651–7.

Ribot T (1896) *La Psychologie des Sentiments*. ParisFelix Alcan.

Richards JB, Zhang L, Mitchell SH *et al.* (1999) Delay or probability discounting in a model of impulsive behavior: effect of alcohol. *J Exp Anal Behav* **71**:121–43.

Rhodes RE, Smith NEI (2006) Personality correlates of physical activity: a review and meta-analysis. *Br J Sports Med* **40**:958–65.

Robinson TE, Berridge KC (1993) The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain Res Rev* **18**:247–91.

Robles E, Huang BE, Simpson PM *et al.* (2011) Delay discounting, impulsiveness, and addiction severity in opioid-dependent patients. *J Subst Abuse Treat* **41**:354–62.

Rogers RE, Higgins ST, Silverman K *et al.* (2008) Abstinence- contingent reinforcement and engagement in non-drug-related activities among illicit drug abusers. *Psychol Addict Behav* **22**:544–50.

Roozen HG, Wiersma H, Strietman *et al.* (2008) Development and psychometric evaluation of the pleasant activity list. *Am J Addict* **17**:422–35.

Roozen HG, Strietman M, Wiersema H *et al.* (2014) Engagement of pleasant activities in patients with substance use disorders: a correlational study. *Subst Abus* **35**:254–61.

Saunders JB, Aasland OG, Babor TF *et al.* (1993) Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction* **88**:791–804.

Schafer JL, Olsen MK (1998) Multiple imputation for multivariate missing-data problems: A data analyst's perspective. *Multivar Behav Res* **33**: 545–71.

Schmaal L, Goudriaan AE, Meer J *et al.* (2012) The association between cingulate cortex glutamate concentration and delay discounting is mediated by resting state functional connectivity. *Brain Behav* **2**:553–62.

Smillie LD, Jackson CJ (2006) Functional impulsivity and reinforcement sensitivity theory. *J Pers* **74**:47–84.

Snaith P (1993) Anhedonia: a neglected symptom of psychopathology. *Psychol Med* **23**:957–66.

Solinas M, Chauvet C, Thiriet N *et al.* (2008) Reversal of cocaine addiction by environmental enrichment. *PNAS* **105**:17145–50.

Spanagel R, Weiss F (1999) The dopamine hypothesis of reward: past and current status. *Trends Neurosci* **22**:521–7.

Strietman M (2006) *Factors Influencing the Engagement of Alternative Behaviors in Substance Dependent Patients*. TilburgTilburg University.

Testa M, Wang W, Derrick JL *et al.* (2019) Does drinking together promote relationship intimacy? Temporal effects of daily drinking events. *J Stud Alcohol Drugs* **80**:537–45.

Van der Linden D, Beckers DGJ, Taris TW (2007) Reinforcement sensitivity theory at work: punishment sensitivity as a dispositional source of job-related stress. *J Pers* **21**:889–909.

Volkow ND, Fowler JS, Wang GJ *et al.* (2002) Role of dopamine, the frontal cortex and memory circuits in drug addiction: insight from imaging studies. *Neurobiol Learn Memory* **78**:610–24.

Volkow ND, Wang GJ, Fowler JS *et al.* (1996) Cocaine uptake is decreased in the brain of detoxified cocaine abusers. *Neuropsychopharmacology* **14**:159–68.

Volkow ND, Wang GJ, Fowler JS *et al.* (2011) Addiction: decreased reward sensitivity and increased expectation sensitivity conspire to overwhelm the brain's control circuit. *Bioessays* **32**:748–55.

Vuchinich RE, Tucker JA (1983) Behavioral theories of choice as a framework for studying drinking behavior. *J Abnorm Psychol* **92**:408–16.

Vuchinich RE, Tucker JA (1988) Contributions from behavioral theories of choice to an analysis of alcohol abuse. *J Abnorm Psychol* **97**:181–95.

Welsh JA, Buchsbaum DG, Kaplan CB (1993) Quality of life of alcoholics and non-alcoholics: does excessive drinking make a difference in the urban setting? *Qual Life Res* **2**:335–40.

Willering JH, Roozen HG, Ooms M *et al.* (2013) *Extraversion Is Associated with Non-Alcohol Related Activities*. TilburgTilburg University.

Willner P (1997) The mesolimbic dopamine system as a target for rapid antidepressant action. *Int Clin Psychopharmacol* **12**:7–14.

Yu R, Branje SJT, Keusers L *et al.* (2011) Psychometric characteristics of Carver and White's BIS/BAS scales in Dutch adolescents and their mothers. *J Pers Assess* **93**:500–7.

Zuckerman M (1993) P-impulsive sensation seeking and its behavioral, psychophysiological biochemical correlates. *Neuropsychobiology* **28**:30–6.