



Contents lists available at ScienceDirect

Personality and Individual Differences

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

Traits linked to executive and reward systems functioning in clients undergoing residential treatment for substance dependence



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ARTICLE INFO

Article history:

Received 2 April 2014

Received in revised form 1 July 2014

Accepted 7 July 2014

Available online 28 July 2014

Keywords:

Addiction
Alexithymia
Frontal lobe

ABSTRACT

Traits presumed to reflect dopaminergic reward and prefrontal executive systems functioning were assessed in 100 clients undergoing residential treatment for substance dependence and a community sample of 107 social drinkers. All participants completed self-report measures of impulsivity, alexithymia, frontal systems dysfunction, sensitivity to rewards and punishments, dispositional mindfulness, alcohol use, illicit drug use, mood and demographic characteristics. The percentage of in-patients meeting the criterion for alexithymia was more than twice as high as in the community sample ($p < .0001$). Multivariate analysis of covariance controlling for age, education, head injury and gender revealed significant differences ($p < .0001$) between clinical and community samples such that clients scored higher on negative moods, frontal systems dysfunction, reward sensitivity, punishment sensitivity and impulsivity, and lower on dispositional mindfulness. Time in treatment was correlated only with negative mood, supporting the stability of the trait measures; controlling for negative mood eliminated group differences on punishment sensitivity and mindfulness only. Results are consistent with the notion that addiction is linked to reward sensitivity and frontal lobe deficits, with associated implications.

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1. Introduction

In recent decades biological perspectives on addiction have emphasised the intertwined roles of (1) the subcortical dopaminergic reward system as a driver of excessive substance use (Koob & Le Moal, 1997; Volkow, Fowler, & Wang, 2004; Wise, 1998) and (2) prefrontal cortex dysfunction as the basis of the impaired self-control that characterises addictive behaviour and relapse (Lyvers, 2000; Schoenbaum & Shaham, 2008; Spinella, 2003; Volkow & Li, 2004). Traits presumed to reflect the functioning of these brain systems include reward sensitivity, often interpreted to index the motivational influence of the dopaminergic reward or behavioural activation system (BAS; Gray, 1987; Torrubia, Avila, Molto, & Caseras, 2001), and traits such as impulsivity, disinhibition, executive deficit and alexithymia (difficulties with identifying and describing one's emotions), which have been linked to abnormalities of prefrontal cortex function as well as risky or problematic substance use (Berthoz et al., 2002; Chen et al., 2007; Dawe, Gullo, & Loxton, 2004; Lyvers, Duff, Basch, & Edwards, 2012; Pinard,

Negrete, Lawrence, & Audet, 1996; Spinella, 2004; Thorberg, Young, Sullivan, & Lyvers, 2009). A combination of inherently high reward sensitivity and deficient executive self-regulation appears to be significantly associated with risky substance use and addiction (Dawe & Loxton, 2004; Dolan, Bechara, & Nathan, 2008; Ivanov, Schulz, London, & Newcorn, 2008; Lyvers, Carlopio, Bothma, & Edwards, 2013; Lyvers, Jamieson, & Thorberg, 2013). Recent attention has also focused on the possible role of mindfulness as a protective factor against addiction and relapse (Bowen & Vieten, 2012). Mindfulness, defined as "awareness and attention to present events and experiences" (Brown & Ryan, 2003, p. 824), appears to reflect higher-order, meta-cognitive functioning (Chambers, Gullone, & Allen, 2009) and is inversely related to impulsivity, alexithymia, and indices of frontal systems dysfunction (Lyvers, Makin, Toms, Thorberg, & Samios, 2013). Mindfulness thus appears to be another aspect of executive cognition.

Based on the notion that addiction is associated with inherently high BAS responsiveness as well as deficiencies in aspects of prefrontal cortex function such as impulse control, mood regulation, and executive cognition (Dawe & Loxton, 2004; Dolan et al., 2008; Ivanov et al., 2008), the present study examined self-report indices of reward sensitivity, frontal systems dysfunction, impulsivity,

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alexithymia, and mindfulness in abstinent, detoxified clients undergoing in-patient treatment for substance dependence and in a comparison sample of non-intoxicated social drinkers from the local community. These measures had previously shown significant correlations with risky substance use in non-clinical community samples for a variety of substances (Lyvers, Carlopio, et al., 2013; Lyvers, Jamieson, et al., 2013; Lyvers et al., 2012; Pinard et al., 1996) but had not previously been examined together in a clinical sample of substance dependent clients. Other variables that were previously found to influence responding on at least some of the measures of interest to the present investigation were also assessed in the present study and their influence controlled via covariate analysis. The clinical sample was expected to score higher than the community sample on measures of negative moods, especially among those early in treatment; but independent of transient mood differences, indices of more stable traits reflecting inherent executive dysregulation (prefrontal cortex) and reward sensitivity (BAS) were expected to be significantly elevated in the addicts, in line with theoretical expectations.

2. Method

2.1. Participants

Substance dependent clients from three Therapeutic Community (TC) addiction treatment centres in southeastern Queensland, Australia, were recruited for the present study over a 10 week period. A \$40 gift voucher was offered as an incentive for participation. Abstinence was confirmed by random urine testing. Residential treatment programs were for a minimum of six months. All client participants were self-referred, had completed more than 14 days in treatment to rule out an influence of detoxification or acute withdrawal on responses, and were not diagnosed with a comorbid neurological or psychological disorder (these were stated criteria for participation). The final clinical sample consisted of 100 TC in-patients undergoing treatment for substance (alcohol and/or illicit drug) dependence (58 males, 42 females; age range 18–63 years, $M = 32.47$, $SD = 11.26$) who on average had been in treatment for 108 days with a range of 17–612 days. The community sample was recruited through advertisements in a local newspaper over the same 10 week period. The advertisements asked for social drinkers who were not currently undergoing treatment for any neurological or psychological disorder. A \$40 gift voucher was specified as an incentive for participation. Interested community members were instructed to attend the university campus where the testing would occur at a pre-arranged time and place. The final community sample consisted of 107 social drinker volunteers from the local southeast Queensland community (43 males, 64 females; age range 18–48 years, $M = 26.65$, $SD = 6.50$). Volunteers from either group were excluded from the final sample if their responses on a demographics and screening questionnaire indicated a current neurological condition (2 addict volunteers). In addition community participants were excluded if their questionnaire responses or alcohol breath test indicated recent intoxication (5 volunteers); if their scores on the Alcohol Use Disorders Identification Test (AUDIT; Babor, de la Fuente, Saunders, & Grant, 1992) or the Drug Use Disorders Identification Test (DUDIT; Berman, Bergman, Palmstierna, & Schlyter, 2003) indicated likely substance dependence (6 volunteers); or if their demographic questionnaire responses indicated previous treatment for a substance problem (1 volunteer). The final samples described above also reflect the exclusion of 8 multivariate outliers identified via Mahalanobis Distance using boxplots. No participants in either sample were of Aboriginal background.

In the clinical sample 21% indicated that alcohol was their primary problem, 11% indicated stimulants (cocaine or

amphetamines), 5% indicated cannabis and 3% indicated opiates such as heroin. The remainder (60%) indicated that their problem involved multiple substances, generally combinations of cannabis, stimulants and/or opiates with alcohol. All participants provided informed consent prior to participation and could withdraw from the study at any time without penalty. Participants were instructed to not provide identifying information on their questionnaires in order to ensure anonymity. The research protocol was approved by the university ethics committee and treatment centres prior to data collection.

2.2. Procedure

Clients were recruited to complete the pen and paper survey by a staff member at the addiction treatment facility. They were asked to place the completed survey in a provided envelope and seal it when finished. The staff member then collected the sealed envelopes and passed them on to the researchers. Community participants completed the same survey in a designated testing room at a local university. They were asked to place the completed survey in a provided envelope, seal it and hand it to one of the researchers when finished. Survey completion required approximately 30–45 min.

2.3. Materials

The following questionnaires were administered to all participants.

2.3.1. Demographics questionnaire

A demographics questionnaire asked for participant age, gender, age at onset of drinking/drug use, years of education, neurological status, current or previous treatment for a substance problem or other psychological disorder, number of days in treatment (clinical sample only), whether they had ever suffered a serious head injury, and recent alcohol or drug use.

2.3.2. Depression Anxiety Stress Scales-21

The Depression Anxiety Stress Scales-21 (DASS-21; Lovibond & Lovibond, 1995) is a 21-item self-report questionnaire consisting of three scales (each with 7 items) designed to measure the emotional states of depression (e.g., "I felt down-hearted and blue"), anxiety (e.g., "I felt scared without any good reason"), and stress (e.g., "I found it hard to wind down") upon reflection of the prior week. Items are rated on a 4-point Likert scale, ranging from 0 = *did not apply to me at all*, to 3 = *applied to me very much or most of the time*. Items are summed within each scale, with higher scores indicating higher levels of depression, anxiety, and stress. In the present study Cronbach's alpha for the overall DASS-21 was .96.

2.3.3. Sensitivity to Punishment and Sensitivity to Reward Questionnaire

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001) is comprised of two subscales, Sensitivity to Punishment (SP) and Sensitivity to Reward (SR). Each subscale has 24 items measuring an individual's motivational propensity to engage in either approach (SR) or avoidance (SP) behaviour in the presence of either rewarding or punishing stimuli, respectively. Items are answered via dichotomous yes (1) or no (0) responses, which are summed for each subscale. The SPSRQ is based on Gray's (1987) Reinforcement Sensitivity Theory (RST), such that the SR scale was designed to evaluate the Behavioural Activation System (BAS) and the SP scale was designed to evaluate the Behavioural Inhibition System (BIS). The SPSRQ has been established as a valid measure of the BAS and BIS components of RST (Caseras, Avila, & Torrubia, 2003; Loxton & Dawe, 2001). In

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