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Behavioral inhibition system (BIS), Behavioral activation system (BAS) and schizophrenia: Relationship with psychopathology and physiology

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Abstract

Objective: The Behavioral Inhibition System (BIS) and the Behavioral Activation System (BAS) have been conceptualized as two neural motivational systems that regulate sensitivity to punishment (BIS) and reward (BAS). Imbalance in BIS and BAS levels has been reported to be related to various forms of psychopathology. Since sensitivity to stress has been supposed to be a pathway for the development of psychotic symptoms, the aim of this study is to examine BIS and BAS scores in schizophrenia and their relationship with psychopathology and physiology.
Method: Forty-two patients with schizophrenia (26 men,16 women), stable on atypical antipsychotics, and 37 healthy controls (17 men, 20 women) were assessed with the use of the Behavioral Inhibition and Behavioral Activation scales. Since increased average heart rate (HR) and decreased heart rate variability (HRV) have been reported in patients with schizophrenia and have been shown to correlate with inhibited behaviour, these psychophysiological measures were also obtained.

The BIS/BAS data and HR/HRV data were both analyzed by a (M)ANOVA. Correlation coefficients were computed for associations between BIS/BAS data, HR/HRV data, and patient variables.
Results: On the BIS, patients showed higher sensitivity to threat than control subjects. Higher BIS sensitivity correlated with longer duration of illness, and lower negative symptoms on the PANSS. The BAS scores did not reveal differences between patients and controls. In patients, low BAS sensitivity correlated with low dosage of medication. On the physiological measures patients showed a significantly higher HR and lower HRV compared to controls, which was limited to clozapine treated patients. No correlations were found between HR/HRV scores and BIS/BAS scores or patient variables.
Conclusions: Male as well as female patients with schizophrenia are more sensitive to threat than healthy controls. This may reflect a trait-related characteristic, and is not reflected in state-related psychophysiological measures.
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Keywords: Behavioral activation system; Behavioral inhibition system; Schizophrenia; Average heart rate (HR); Heart rate variability (HRV)

1. Introduction

Gray (1976, 1987, 1994) conceptualized two neural motivational systems that regulate the intensity of approach and withdrawal behaviour in response to environmental stimuli: the Behavioral Activation System (BAS) and the Behavioral Inhibition System (BIS). BAS is hypothesized to control approach behaviour in response to cues of reward via dopaminergic activity in the mesolimbic system (Depue and Collins, 1999; Gray, 1994), whereas BIS is hypothesized to be sensitive to cues of threat and punishment and to activate responses of inhibition and avoidance via noradrenergic and serotonergic activity in

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the septohippocampal system (Depue and Jacono, 1989; Gray, 1982, 1994). Recently, Gray's theory has been adapted, viewing the BIS being distributed among a number of neural structures controlled by the septo-hippocampal system and the amygdala and regarding the BIS as sensitivity to conflicts in general (Gray and McNaughton, 2000; McNaughton and Corr, 2004).

Sensitivity of the BIS/BAS systems is biologically based, while reactivity of the systems is conditioned by environmental input. Therefore, individual differences in risk factors and protective factors (e.g. gender differences in socialization with respect to reward and punishment conditioning) will affect the sensitivity to punishment and reward. Gray's theory is one of the most influential biologically based personality theories, and has motivated research in the neurophysiological (e.g. Blair, 2003; Coan and Allen, 2003; Cools et al., 2005; Hawk and Kowmas, 2003; Keltinkangas-Järvinen et al., 1999; Reuter et al., 2005; Sutton and Davidson, 1997), and the molecular genetic basis of the BIS and BAS systems (Cools et al., 2005). For instance, this research has shown that BIS scores predict serotonergic modulation of amygdala responses to fearful faces (Cools et al., 2005) and that the interaction of COMT and DRD2 polymorphisms predicts variations in the behavioral approach system (Reuter et al., 2005).

Although there have been previous attempts to measure Gray's BIS/BAS dimensions, these have all been hampered by considerable conceptual and psychometric problems. Therefore Carver and White (1994) developed a brief questionnaire to measure BIS and BAS sensitivities, focussing mainly on the emotional consequences of BIS/BAS sensitivity. The BIS items assess responsiveness to impending punishing events and the BAS items assess responsiveness to reward (BASR), funseeking (BASF), and drive towards appetitive goals (BASD) in 3 sub-scales. The Carver and White scales are the most comprehensive and specific measure of BIS/BAS sensitivities. Several validation studies found support for the validity of this BIS/BAS scales (Campbell-Sills et al., 2004; Heubeck et al., 1998; Jorm et al., 1999), and showed the generalizability across samples ($n = 646$) from the USA, UK and Italy (Leone et al., 2001). In clinical studies(Carver et al., 2000; Kasch et al., 2002) BIS/BAS levels, assessed with this questionnaire, proved to be stable over time and clinical state, being more a measure of trait (correlating with measures of personality constructs) than of state (correlating with measures of current clinical symptoms).

Sex differences have been reported for the BIS/BAS scales, with women showing higher sensitivity on the BIS (Leone et al., 2001). Externalizing disorders, including substance abuse and antisocial behaviour, are more frequent in men (Rosenfield, 2000), and have been found to be significantly associated with higher BAS scores (Newman et al., 1997, 2005).

Overactivity and underactivity in the BIS and BAS systems, and relative imbalance between BIS and BAS systems, have been related to risk for various forms of psychopathology (Johnson et al., 2003). For example, depression has been shown to be associated with high sensitivity on the BIS and low sensitivity on the BAS (Kasch et al., 2002), bipolar disorder with both elevated BIS and BAS (Depue and Jacono, 1989; Johnson et al., 2000; Meyer et al., 2001), anxiety disorder (Carver, 2004), nervousness and high levels of internalizing behaviour (Colder and O'Connor, 2004) with high BIS sensitivity, and Attention Deficit Hyperactivity Disorder (ADHD) with low BIS sensitivity (Matthys et al., 1998). Higher sensitivity to reward (BAS) has been suggested to underlie psychopathy, and high levels of externalizing problems (Newman et al., 1997, 2005). Surprisingly, to date, the BIS/ BAS scales have not been investigated in patients with schizophrenia. However, in a study by Berenbaum and Fujita (1994) patients with schizophrenia have been found to show increased neuroticism and decreased extraversion compared to controls. Therefore, we hypothesized patients to show higher sensitivity to punishment (BIS) than control subjects.

Excessive phasic dopaminergic transmission has been suggested to underlie psychotic (positive) symptoms and increased emotional reactivity in schizophrenia (Aleman and Kahn, 2005; Davis et al., 1991). Since the mesolimbic system is involved in behavioral reinforcement and motivation, and since the role of the dopaminergic reward system is to direct attention towards reward-indicating stimuli and to predict reward, excessive dopaminergic transmission may result in over-attribution of meaning to otherwise irrelevant cues. Reduced dopamine receptor sensitivity in the striatum, increased by neuroleptics, is associated with negative symptoms (avolition, apathy, affective flattening) (Heinz et al., 1998) and may reduce motivational and emotional responses to reward-indicating situations. (Robbins and Everitt, 1996; Schultz et al., 1997). Therefore we expected higher sensitivity to reward (BAS) to correspond to high levels of positive symptoms, and lower sensitivity to reward to high levels of negative symptoms.

With regard to sex differences, a recent study by Myin-Germeys et al. (2004) indicated that women with psychotic symptoms reacted more strongly to daily life stress than men, with increase in negative affect and decrease in positive affect. Since women have been found to show higher sensitivity on the BIS (Jorm et al., 1999; Leone et al., 2001), and more internalizing problems than men (Rosenfield, 2000), we also expected women with schizophrenia to be more sensitive to threat (i.e., elevated BIS scores) than men with schizophrenia.

Several studies have reported increased average heart rate (HR) (Rechlin et al., 1994, 1995; Zahn et al., 1981a,b, 1997) and decreased heart rate variability (HRV) (Bär et al., 2005), in patients with schizophrenia. Since increased HR and decreased HRV have been shown to correlate with inhibited behaviour (Kagan et al., 1987, 1988; Reznick et al., 1986) these psychophysiological measures were also obtained. We expected high BIS sensitivity

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