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Pathological gambling: Relation of skin conductance response to dopaminergic neurotransmission and sensation-seeking

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Abstract

Absent Skin Conductance Response (SCR) in pathological gambling (PG) may relate to dopaminergic mechanisms. We recruited equal numbers of PG subjects and healthy control (HC) subjects, and then tested the claim that SCR is less conditioned by dopaminergic activity in PG subjects. During active gambling, SCR differed in PG and HC subjects ($P<0.05$), but positron emission tomography revealed the same dopamine receptor availability. However, highly sensation-seeking (HS) PG subjects had lower dopamine receptor availability ($P<0.0001$) in the baseline, compared to normal sensation-seeking (NS) PG subjects. We find that HS versus NS controls had the same observation of significant increase of binding potential (BP_{ND}) in high compared to normal sensation seekers. In both groups, PG and HC, highly sensation-seeking subjects had significant increase of receptor availability in striatum, compared to normally sensation-seeking subjects, separately ($P<0.05$ and $P=0.02$, respectively) and together ($P<0.0005$). We conclude that SCR is less conditioned by dopaminergic activity in highly sensation-seeking subjects, regardless of PG status.

1. Introduction

There is strong evidence of a key role of dopaminergic neurotransmission in learning. We examined the relationship

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between the SCR as a somatic marker and dopaminergic neurotransmission as a factor in the learned behavior of PG subjects compared to HC subjects. Dopamine (DA) originates in the projections from the substantia nigra and ventral tegmental area to the striatum and the mesolimbic and mesocortical systems. According to the self-perceived survival and fitness (SPSF) theory, the latter DA systems are involved in the learning of survival and reproduction skills (Newlin, 2007). The Somatic Marker Hypothesis (SMH) in turn maintains that somatic states affect the decisions required of learned behavior (Damasio, 1994). According to Bechara and Damasio (2005), somatic states are changed by the release of neurotransmitters in the telencephalon and diencephalon. Indeed, the findings of Sevy et al. (2006) suggest that somatic markers affect decisions by changing dopaminergic neurotransmission. As a somatic marker, the SCR is a reaction to predicted adversity that reflects the effect of aversively conditioning stimuli (CS) on DA release (Schultz, 1998). Fowles' "Three Arousal Model" (Fowles, 1980) contends that SCR variability is influenced by the parasympathetic autonomic nervous system's reaction to aversive consequences (Goudriaan et al., 2006).

According to this evidence, attenuation of the SCR in some people reduces their ability to emotionally anticipate consequences of recent choices. Differences in response among healthy individuals may be associated with personality traits such as sensation-seeking, defined by Zuckerman's sensation-seeking (ZSS) scale (Zuckerman, 1994), and differences of dopaminergic neurotransmission exist among individuals with different scores on the ZSS scale (Gjedde et al., 2010). Hence it is possible that attenuation of the SCR in situations normally linked to adversity is associated with abnormal DA release.

When a risky choice is made by a healthy individual, the anticipated reward or punishment triggers a somatic state, which in turn marks the predicted outcome as positive or negative (Naqvi and Bechara, 2006). We reasoned that highly sensation-seeking individuals fail to sufficiently condition the SCR to a central dopaminergic activation that normally prevents pathological behavior. This failure affects decisions during gambling, in a manner similar to the affected decisions of substance abusers and sufferers of brain lesions (Bechara et al., 1996; Bechara and Damasio, 2002).

The Iowa gambling task (IGT) is an experimental test of decision-making that depends on uncertainties of reward and punishment (Dunn et al., 2006). In a study using the IGT, Goudriaan et al. (2006) found that PG subjects have lower SCR, lower heart rate (HR) and poorer performance on the IGT compared to HC subjects. The HR fell whether the PG subjects won or lost, compared to HC subjects who had higher HR after winning and lower HR after losing.

In this study, we coupled the IGT to the psychophysiological measurement of SCR on the basis of the claim that individuals who suffer from addictive behavior fail to condition the SCR to adverse outcomes (Bechara, 2004). We reasoned that abnormal release of DA during inadequate SCR could signify unfounded expectations of advantageous outcome of risky behavior, consistent with the evidence that DA release is linked to the outcome of monetary reward tasks (de la Fuente-Fernandez et al., 2002; Steeves et al., 2009).

1.1. Primary hypothesis

On the basis of the theory that individuals learn from effects of a somatic marker such as the SCR, we tested the claim that a link between SCR and DA release differs in PG and HC subjects when these subjects gamble actively. We predicted that PG subjects recruit less of the SCR mechanism conditioned by central dopaminergic activity than HC subjects, specifically that the binding potential (BP_{ND}) would decline less in PG subjects because of attenuated DA release during gambling.

1.2. Secondary hypothesis

We further reasoned that differences of sensation-seeking propensity could exist among PG and HC subjects, which could mask differences between PG and HC subjects as single groups. We therefore tested the claim that SCR is less conditioned by dopaminergic activity in highly sensation-seeking (HS) than in normally sensation-seeking (NS) subjects.

We defined active gambling as the activity of an individual who actively makes choices on the IGT. To test the hypotheses, i.e., to test whether execution of an active experimental gambling task is associated with specific changes of DA receptor availability (binding potential) and a specific autonomic reaction such as the SCR, we determined the SCR and changes of dopaminergic neurotransmission in striatum. We used positron emission tomography to measure changes of [^{11}C]raclopride binding to DA receptors, simultaneously with changes in SCR and performance on the IGT.

2. Experimental procedures

2.1. Subject recruitment

The Research Ethics Committee of the Central Region of Denmark approved the study. Informed consent was obtained from all subjects and nominal compensation was given. We recruited two groups of 11 subjects each, one group of HC subjects, and one group of individuals who matched the criteria of PG. The subjects were right-handed men between the ages of 22 and 55. We used the nonparametric chi-square test to compare the proportions of HS and NS in the two groups. The 11 pathological gamblers were recruited from the local Center of Pathological Gambling as actively gambling subjects who had not yet entered treatment. The matching 11 HC subjects were recruited by local newspaper advertisement.

Subjects were assigned to HS or NS categories based on their ZSS scale score above or below the population average plus one standard deviation. The population average (19.7±5.2 SD) was determined from a normally distributed sample of 243 healthy Danes on the 40-point ZSS scale (Zuckerman, 1994). The dividing score therefore was 24.9. The average age was 36.5 years for the HS group (n=10) and 31.5 years for the NS group (n=12).

All participants were screened with the Structured Clinical Interview for DSM-IV (SCID) (First, 1995; American Psychiatric Association, 1994), South Oaks Gambling Score (SOGS) (Lesieur and Blume, 1987; 1993), Beck Depression Inventory (Beck and Steer, 1984; Beck et al., 1961), and the SCI-PGI (Grant et al., 2004), a special SCID module for PG. The PG candidates were included when they met full Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (1994) criteria for PG. HC subjects were excluded if they had more than one symptom on the SCI-PGI