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Effects of cigarette smoking status on delay discounting in schizophrenia and healthy controls

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ABSTRACT

Background: Delay discounting is a measure of future-oriented decision-making and impulsivity. Cigarette smoking is associated with rapid discounting of the value of delayed outcomes. In schizophrenia, however, cigarette smoking improves certain neurocognitive impairments associated with the disorder which may explain the high smoking rates in this population. This study examined the relationship between cigarette smoking and delay discounting in schizophrenia and control participants.
Methods: A total of N = 130 participants, including those with schizophrenia (n = 68) and healthy controls (n = 62) were assessed on the Kirby Delay Discounting Task and compared across smoking status (smokers; non-smokers) and smoking history (current, former; never smokers).
Results: Smokers exhibited higher discounting rates (i.e., were more impulsive) than non-smokers of the same diagnostic group. Current and former smokers with schizophrenia exhibited similar and significantly higher discounting rates than never smokers, suggesting that in schizophrenia delay discounting is a trait-dependent phenomenon independent of current cigarette smoking. Consistent with previous studies, there was a trend for higher discounting rates in control current smokers compared to control former and never smokers.
Conclusions: Smokers with and without schizophrenia have higher rates of delay discounting than non-smokers. However, in schizophrenia, rapid delay discounting appears to be a trait associated with having ever been a smoker (i.e., current and former smoking).

1. Introduction

Patients with schizophrenia are nearly three times more likely to smoke than the general population and have more difficulty in quitting smoking (George et al., 2008; Kalman, Morissette, & George, 2005; Weinberger et al., 2007). There is evidence to suggest that cigarette smoking may be an attempt to ameliorate some of the cognitive deficits associated with schizophrenia (George, 2007). For example, in schizophrenia, nicotine and cigarette smoking can improve certain domains of cognitive function, particularly those related to prefrontal cortex (PFC) function (e.g., spatial working memory) (Sacco et al., 2005; Smith, Singh, Infante, Khandat, & Kloos, 2002); those who have the most severe PFC-related neuropsychological impairment are the least likely to achieve trial endpoint smoking cessation (Dolan et al., 2004; Moss et al., 2009); and abstinence from smoking results in a further decline in cognitive performance (George et al., 2002; Sacco et al., 2005). However, less attention has been paid to the relationship between cigarette smoking in schizophrenia and other domains of cognitive function such as impulsivity. This is particularly surprising given that impulsivity is a well-recognized feature of schizophrenia (Heerey, Robinson, McMahon, & Gold, 2007; Kester et al., 2006) and also plays a key role in the development and maintenance of drug addiction (Bickel, Odum, & Madden, 1999; Krishnan-Sarin et al., 2007).

Impulsivity is a complex, multidimensional trait encompassing a range of behaviors including but not limited to, failure to inhibit inappropriate responses to prepotent stimuli and a tendency to value smaller immediate rewards over larger future ones (often referred to as delay discounting; DD) (Meda et al., 2009). In the laboratory, DD is often assessed using a 27-item questionnaire which assesses preferences for hypothetical rewards over different delay durations (Kirby, Petry, & Bickel, 1999). Studies have demonstrated that there is a hyperbolic, rather than exponential or linear, relationship between the subjective value of a reward and the delay duration (Madden, Petry, Badger, & Bickel, 1997).

It is well known that drug dependent individuals typically prefer relatively brief and immediate rewards (i.e. drug intoxication or relief of transient withdrawal symptoms) over a variety of pro-social, but

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often deferred, rewards (Kreek, Nielsen, Butelman, & LaForge, 2005; Mitchell, 1999); this is reflected by the rapid rates of DD found among substance abusers (Kirby et al., 1999). With regards to cigarette smoking, research suggests that traits associated with appetitive reward-seeking behavior, such as impulsivity, may increase one's vulnerability to tobacco dependence (Bickel et al., 1999; Doran, Spring, McChargue, Pergadia, & Richmond, 2004) as well as the inability to maintain abstinence (Krishnan-Sarin et al., 2007). Adults who smoke cigarettes discount the value of delayed monetary rewards more than occasional, ex-, and never smokers (Bickel et al., 1999). Within smokers, high rates of DD appear to be associated with the level of both cigarette consumption (Reynolds, 2004) and dependence. Scores on the Fagerstrom Test of Nicotine Dependence (FTND) predicted DD, independent of the number of cigarettes smoked per day (Sweitzer, Donny, Dierker, Flory, & Manuck, 2008), and similarly, nicotine dependent cigarette smokers discounted delayed rewards at higher rates than those who smoke cigarettes regularly but were not dependent (Heyman & Gibb, 2006).

Various psychiatric disorders have also been associated with high rates of DD including obsessive–compulsive disorder (Cavedini et al., 2002; Lawrence et al., 2006), anorexia nervosa (Cavedini et al., 2004), mood disorders (Murphy et al., 2001; Must et al., 2006) and schizophrenia (Heerey et al., 2007; Kester et al., 2006). Heerey et al. (2007) examined DD in stable outpatients with schizophrenia and healthy controls and found that patients chose immediate over delayed rewards more often than controls (2007). However, unlike non-psychiatric populations, the relationship between cigarette smoking and delay discounting in schizophrenia has not been examined. Therefore the goal of the current study was to examine DD in smokers and non-smokers with schizophrenia in comparison to non-psychiatric controls.

It is also of interest to know whether DD is a state-dependent effect of cigarette smoking or a trait-related phenomenon which may be a risk factor for the initiation of cigarette smoking. Bickel et al. (1999) investigated this theory in individuals without a psychiatric diagnosis by comparing current, ex-, and never smokers. Current smokers discounted the value of delayed money more than both ex- and never smokers, with the latter two having similar DD rates. This suggests that the high rates of DD observed in current smokers may be a reversible, state-dependent effect of cigarette smoking (Bickel et al., 1999). Therefore the secondary exploratory aim of this study was to investigate the effects of smoking history on DD in patients with schizophrenia and controls by comparing current, former and never smokers.

2. Methods

2.1. Participants

Data were obtained in two cross-sectional studies that examined the effects of cigarette smoking on cognitive function in patients with schizophrenia and controls. A total of 130 participants were studied: 68 outpatients with a diagnosis of schizophrenia or schizoaffective disorder (n = 33 smokers; n = 35 non-smokers) and 62 healthy control participants (n = 23 smokers; n = 39 non-smokers). Non-smokers were further classified into former and never smokers to investigate the effects of smoking history on DD in schizophrenia (33 current, 12 former and 23 never smokers) and control participants (23 smokers, 11 former, and 28 never smokers).

Recruitment procedures for controls were aimed at community members within the Greater Toronto Area and involved newspaper advertisements and internet postings. Outpatients at the Centre for Addiction and Mental Health (CAMH) were recruited through means of flyers, word-of-mouth, and referrals from clinicians. Study procedures were approved by the CAMH Research Ethics Board and participants were compensated for their participation in the study.

2.2. Inclusion and exclusion criteria

Participants were aged between 18 and 60, provided informed consent and were evaluated using the Structured Clinical Interview (SCID) for the DSM-IV (First, Spitzer, Robert, Gibbon, & Williams, 1996). Participants with schizophrenia were psychiatrically stable, had a score less than 70 on the Positive and Negative Syndrome Scale (PANSS) (Kay, Fiszbein, & Opler, 1987), and were maintained on a stable dose of antipsychotic medication for at least one month. Control participants did not meet criteria for any current Axis I disorders. Participants had not abused or been dependent on illicit drugs or alcohol in the past six months and urine toxicology was conducted to test for illicit drug use (Medtox®; Wilmington, NC). Current use of nicotine replacement products was exclusionary. An estimate of premorbid IQ was obtained by administering the National Adult Reading Test (N = 89) (Nelson & Willison, 1991; Russell et al., 2000) or the Shipley-2 (N = 41) (Shipley, Gruber, Martin, & Klein, 2009).

Cigarette smoking status was assessed via self-report and biochemically verified with expired breath carbon monoxide (CO) levels. Eligible smokers reported smoking ≥10 cigarettes per day on average, had expired CO levels ≥10 parts per million (ppm), and scored ≥4 on the Fagerstrom Test of Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; Weinberger et al., 2007). Non-smokers had CO levels <10 ppm. Former smokers had been abstinent from cigarettes for ≥6 months and never smokers reported smoking <100 cigarettes in their lifetime (Benowitz, Hansson, & Jacob, 2002).

2.3. Neuropsychological testing

The Kirby Delay Discounting Task (KDDT) was administered as part of a larger neuropsychological testing session. Participants were permitted breaks as often as they required. Smokers were not required to smoke during breaks but were permitted to smoke ad libitum in an attempt to replicate the subjects' naturalistic smoking behavior (Sacco et al., 2005).

2.3.1. Kirby Delay Discounting Task (KDDT)

The KDDT is a 27-item questionnaire that assesses discounting of hypothetical monetary amounts over time and across three different delayed-reward magnitudes: small ($25–$35), medium ($50–$60), and large ($75–$85). Participants are asked to choose between a smaller immediate reward and a larger delayed reward (e.g., "Would you prefer $20 today or $55 in 7 days?"). The KDDT has good internal consistency of discount rates for the three different reward magnitudes, and adequate test–retest reliability (Kirby et al., 1999). A hyperbolic discount parameter (k) was estimated, for each reward magnitude, from the subject's choices between immediate and delayed rewards using the methods reported by Kirby (2000); smaller k values reflect less discounting. A mean was calculated to provide an estimate of k across all reward magnitudes.

2.4. Statistical analysis

Statistical analysis was conducted using SPSS (v.15.0; Chicago, IL). Demographic and clinical characteristics were analyzed by Chi-square for categorical measures and analyses of variance (ANOVA) for continuous measures; Bonferroni pairwise comparisons are reported. DD data were tested for normality using the Shapiro–Wilk test; as the data were not normally distributed all k values were transformed using a natural log (Ln) function to improve normality. It should be noted that logarithms of quantities less than 1.0, as is the case for k, are larger in absolute terms when k is smaller (i.e., closer to 0), as a result more negative Ln (k) values reflect *less* discounting. The transformed k values were analyzed using three-factor ANOVAs for the within-subject factor of reward size (small, medium and large) and the between-subject