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Short communication

Lack of inhibitory control predicts cigarette smoking dependence: Evidence from a non-deprived sample of light to moderate smokers

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ABSTRACT

Objective: To examine the relationship between prepotent inhibition capacities and cigarette dependence in a sample of non-deprived light to moderate smokers.
Methods: Fifty volunteer smokers were screened with a laboratory go-stop paradigm, and self-reports of cigarette dependence (Fagerström Test for Nicotine Dependence, FTND) and cigarette craving (revised Questionnaire on Smoking Urge, QSU-12).
Results: Correlation and regression analyses showed that lower prepotent inhibition capacities predict higher levels of cigarette dependence when individual differences in processing speed, craving states, and age were controlled for. In addition, lower inhibition capacity is associated with a higher number of cigarettes smoked per day.
Conclusions: A poor ability to inhibit prepotent responses seems to be one of the individual factors related to cigarette smoking dependence.

1. Introduction

A variety of psychological factors have been shown to play a role in addictive behaviours (e.g. executive functions, impulsivity, personality traits, reinforcement sensitivity, attentional bias). A growing body of evidence suggests that addictive behaviours are associated with impairments in prepotent response inhibition, that is, the capacity to deliberately control or suppress an automatic behaviour (Groman et al., 2009). Indeed, control participants perform significantly better on laboratory tasks assessing prepotent response inhibition (e.g. go/no-go tasks, stop-signal tasks) than do persons who abuse substances such as cocaine (Fillmore and Rusch, 2002), methamphetamine (Monterosso et al., 2005), marijuana (Ramaekers et al., 2006), or alcohol (Li et al., 2009). Accordingly, it has been proposed that individuals with poor inhibitory control experience greater difficulties not consuming substances in reaction to strong substance-approach motivations, despite the potential negative consequences (e.g. Gullo and Dawe, 2008).

A few studies have investigated inhibition capacities of smokers compared with non-smokers. The majority of these studies did not find differences in inhibitory control (measured with go/no-go or stop-signal tasks) between non-smokers and light smokers (approximately 5–10 cigarettes per day; Dinn et al., 2004; Reynolds et al., 2007) or heavier smokers (at least 15 cigarettes per day, Monterosso et al., 2005). Only one study found smokers to be less efficient in inhibitory control (measured with a go/no-go task) than control participants (Spinella, 2002). Unfortunately, no information concerning the smokers was provided in the study (e.g. exact number of cigarettes smoked per day).

Interestingly, recent data support that individual differences in inhibitory control may play a role in the heaviness of smoking. More precisely, Spinella (2002) reported that the errors in a go/no-go task are positively correlated with the number of cigarette packs smoked daily, and Glass et al. (2009) found that lower inhibition capacities (measured with a stop-signal task) are associated with a higher consumption of cigarettes. In the latter study, smoking was measured with an index computed by multiplying average daily use (in packs) by the number of years of smoking. Consequently, individual differences in inhibition seem to be related to the heaviness of smoking. In addition, Krishnan-Sarin et al. (2007) found that adolescents who successfully complete a smoking cessation program have a lower rate of inhibition errors in a go/no-go task than do those who quit the program before its end.

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Taken conjointly, these findings do not support the concept that smokers are impaired in inhibition compared with non-smokers, whereas it seems that smokers with lower inhibition capacities are prone to consume more cigarettes. Nevertheless, the potential impact of individual differences in the ability to inhibit a prepotent response at the level of cigarette dependence remains unexplored.

The objective of the current study was to further investigate the relationship between inhibitory control and cigarette dependence in a sample of light to moderate smokers. Studies on light and moderate smokers are of much interest because the prevalence of such smoking profiles has greatly increased in recent years with the implementation of strong tobacco control policies and restrictions by many countries (e.g. Shiffman, 2009). The study was also motivated by the fact that heavy smoking (in contrast to light smoking) frequently co-occurs with psychiatric problems associated with inhibition impairment (e.g. drug abuse, Monterosso et al., 2005). No control group was used, as our goal was to explore the role of individual differences in inhibition among smokers and not to undertake another study designed to compare inhibition in smokers versus non-smokers.

2. Methods

2.1. Participants and procedure

A total of 50 smokers (28 women, 22 men), recruited via advertisement at the University of Geneva, took part in the study. The mean age of the sample was 25.66 years (*SD* = 5.28) and the mean number of years of schooling was 15.76 (*SD* = 2.78). Participants were non-deprived smokers at the time of the experiment. Inclusion criteria consisted of being a light to moderate smoker (smoking up to 20 cigarettes daily) and a native or fluent speaker of French. Exclusion criteria comprised other substance use or a reported history of brain injury or psychiatric problems. Participants first completed a demographic sheet and a questionnaire about their craving for cigarettes, then performed a laboratory task that taps into prepotent response inhibition, and finally were screened with a questionnaire about smoking dependence. The questionnaires and the laboratory task were administered in conditions that guaranteed anonymity.

2.2. Materials

2.2.1. Go-stop task. The go-stop task (adapted from Dougherty et al., 2005) was used to assess inhibition capacities. In the first part of the task, which is intended to build a prepotent response, 40 trials were conducted in which a cue stimulus (a black number composed of five digits) was followed (after a 1-s blank screen) by a target stimulus (the same black number composed of five digits). Each stimulus was presented for 500 ms. Participants were instructed to press a response button as quickly as possible when the target appeared. The second part of the task was composed of two blocks of 100 trials identical to those in the first block, but for a random 25% of the trials, the second matching number changed colours from black to red, indicating a stop signal. Indeed, participants were told to inhibit their responses when the go-signal numbers changed colour (stop signal). The Stop Signal Delay (SSD) was set at 250 ms initially and then adjusted dynamically depending on the participant's responses: the delay increased by 50 ms in case of successful inhibition and decreased by 50 ms in case of failed inhibition. This tracking algorithm adjusted the SSD to obtain an overall response inhibition percentage of approximately 50%. The dependent variable that reflects the latency of the inhibitory process is the Stop Signal Reaction Time (SSRT), which corresponds to the latency of the inhibitory process (high SSRTs correspond to lower inhibition capacities). The SSRT was calculated by subtracting the SSD (at which inhibition was approximately 50%) from the go reaction time (see Logan, 1994). To limit the impact of late responses, every no-stop trial that is longer than the mean for no-stop trials plus 2.5 standard deviations is suppressed on a subject-by-subject basis.

2.2.2. Fagerström Test for Nicotine Dependence (FTND). The French version of the FTND (Etter et al., 1999) assesses the level of smoking dependence. The FTND is a self-report instrument with six items rated either from 0 to 1 or from 0 to 3 (depending on the question) that can yield a total score of 10, with higher scores indicating greater dependence. The FTND has been used in many studies and shown to have positive correlations with several biochemical measures related to the quantity of cigarettes smoked (e.g. saliva cotinine; Heatherton et al., 1991); its internal consistency and test–retest reliability are good (Pomerleau et al., 1994). Scores on the FTND (range: 0–8; *M* = 2.07, *SD* = 2.07) showed that participants are light to moderate smokers who consume either less than 10 cigarettes per day (25 participants) or between 10 and 20 cigarettes per day (25 participants).

2.2.3. Revised Questionnaire on Smoking Urges (QSU-12). The revised version of the QSU-12 (Toll et al., 2004) consists of 12 items evaluating urges for cigarettes in two distinct facets of craving: (1) the intention and desire to engage in cigarette smoking, which is believed to be pleasant (desire to smoke scale, 6 items); and (2) the relief of negative affect or withdrawal through smoking (negative affect scale, 6 items). In order to use the QSU-12 in French, we selected the corresponding 12 items from the French validation of the original 32-item Questionnaire on Smoking Urges (Guillin et al., 2000). Items are scored from 1 'I disagree strongly' to 7 'I agree strongly'.

2.3. Statistical analyses

Pearson's correlations were used to evaluate the relationships between variables. A student *t*-test was computed to compare inhibition in participants smoking less than 10 cigarettes per day (*N* = 25) and those smoking between 11 and 20 cigarettes per day (*N* = 25). A 2-step hierarchical multiple regression analysis was performed to examine the specific contribution of inhibition capacities in cigarette dependence while controlling for age, craving, and processing speed. Age was entered in the regression because older participants have probably smoked for a longer period, which could play a role in their level of dependence. Craving was entered in the regression because a high desire for tobacco at the time of testing could have had a negative impact on performance in the inhibition task (e.g. by promoting cigarette smoking-related intrusive thoughts). Mean reaction times in the go-stop task were entered in the regression to take into account individual differences in processing speed. Age, scores on the QSU-12, and go reaction times were entered in the first step as control variables, followed by the SSRT as a main predictor in the second step. Inspection of residuals and multicollinearity effects showed that the conditions of application for regression analyses were respected. Several variables were transformed by using natural logarithms to decrease the skewness of their distribution (FTND, reaction times in the go-stop task).

3. Results

Descriptive statistics and correlation analysis are reported in Table 1. A significant relationship between the SSRT and the FTND was found, indicating that poor inhibition capacities are associated with higher levels of nicotine dependence. The two factors of the QSU-12 were correlated, as were reaction times and the SSRT in the go-stop task. No other significant correlation was found. A student *t*-test revealed that participants who smoke less than 10 cigarettes per day have higher inhibition capacities than do those who reported smoking between 11 and 20 cigarettes per day, $t(48) = -2.11$, $p = 0.04$.

Table 1
Cronbach's alphas, means, standard deviations for study variables and zero-order Pearson's correlations among study variables.

	α	*M* (*SD*)	(1)	(2)	(3)	(4)	(5)
(1) Age		25.66 (5.28)	–				
(2) Go-stop – RT		449.51 (91.71)	−0.21	–			
(3) Go-stop – SSRT		237.15 (44.32)	−0.01	0.53**	–		
(4) QSU-12 – I	0.84	21.14 (8.65)	−0.26	0.27	0.07	–	
(5) QSU-12 – R	0.70	10.10 (4.13)	−0.11	0.20	0.18	0.60**	–
(6) FTND	0.70	2.07 (2.07)	0.28	−0.02	0.28*	0.20	0.19

Note: *N* = 50. Pairwise treatment of missing data (Age: *N* = 47; QSU: *N* = 49). QSU-12 – I = Revised Questionnaire on Smoking Urges – intention and desire to smoke subscale; QSU-12 – R = Revised Questionnaire on Smoking Urges – relief from negative affect subscale; SSRT = Stop Signal Reaction Time; RT = Reaction Time; FTND = Fagerström Test for Nicotine Dependence.

* $p < 0.05$.

** $p < 0.01$.

Table 2
Hierarchical regression analyses predicting FTND by inhibition capacities when controlling for age, craving, and processing speed.

Dependent variable		Predictors	Beta	t	Sig.	R^2	R^2 change
FTND	Step 1	Age	0.35*	2.31	0.03	0.16	
		QSU-12 – I	0.25	1.31	0.20		
		QSU-12 – R	0.08	0.47	0.64		
		Go-stop – RT	−0.03	−0.19	0.85		
	Step 2	Go-stop – SSRT	0.39*	2.39	0.02	0.27*	0.11*
		Age	0.32*	2.22	0.03		
		QSU-12 – I	0.31	1.75	0.09		
		QSU-12 – R	0.01	0.07	0.94		
		Go-stop – RT	−0.25	−1.45	0.15		

Note: $N = 50$. Pairwise treatment of missing data (Age: $N = 47$; QSU: $N = 49$). Predictors are listed in decreasing order of importance. QSU-12 – I = Revised Questionnaire on Smoking Urges – intention and desire to smoke subscale; QSU-12 – R = Revised Questionnaire on Smoking Urges – relief from negative affect subscale; SSRT = Stop Signal Reaction Time; RT = Reaction Time; FTND = Fagerström Test for Nicotine Dependence.
* $p < 0.05$.

As illustrated in Table 2, a hierarchical regression emphasized that cigarette dependence is significantly predicted by inhibition capacities, even after controlling for the effect of age, craving, and processing speed. More precisely, results from step 2 reveal that SSRT predicted a significant amount of variance in FTND ($\Delta R^2 = 0.11$; $F(1, 40) = 5.71$; $p < 0.05$). Regression analysis also showed that age is a significant predictor of cigarette dependence.

4. Discussion

The aim of the present study was to examine whether individual differences in inhibitory control predict cigarette smoking dependence among light to moderate smokers. Correlation and regression analyses demonstrated that lower inhibition abilities predict higher levels of cigarette dependence when individual differences in processing speed, craving state, and age were controlled for. Moreover, results also showed that lower inhibition capacity is associated with a higher number of cigarettes smoked per day.

First, the present study confirms and extends previous results emphasizing that smokers characterized by low inhibition capacities consume more cigarettes (Glass et al., 2009; Spinella, 2002). However, our results not only showed that low inhibition is associated with higher smoking (reflected by an approximation of the number of cigarettes smoked per day), but they also revealed inhibition to be a predictor of the severity of smoking as measured by the FTND (e.g. difficulties in not smoking in certain contexts, less time since first cigarette smoked).

These findings are in accordance with the view that weak inhibitory control is central to the development and persistence of addictive behaviours (e.g. Goldstein and Volkow, 2002; Gullo and Dawe, 2008). More specifically, it may be supposed that smokers with poor inhibition capacities find it more difficult not to smoke when they are faced with certain specific internal or external cues (e.g. a negative affect state promoted by nicotine withdrawal; seeing someone else lighting a cigarette), which will ultimately lead to heavier smoking and a greater likelihood of becoming addicted to cigarettes.

It should be noted here that age is also a predictor of cigarette dependence. A possible explanation for this finding lies in the fact that older participants have probably smoked for a longer time, which result in stronger dominant smoking behaviours and promotes cigarettes smoking and dependence. Unfortunately, this explanation remains tentative, as the participants were not asked about their years of smoking.

To conclude, the present data encourage the development of psychological interventions for smoking cessation that target the management of inhibition problems.

Conflict of interest

All authors declare that they have no conflicts of interest.

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No funding was provided for that study.

Contributors

Joël Billieux and Martial Van der Linden designed the study. Joël Billieux, Martial Van der Linden, Philippe Gay, and Lucien Rochat contributed to writing the manuscript. Joël Billieux undertook the statistical analysis. Yasser Khazaal, Daniele Zullino, and Martial Van der Linden contributed to the editing and review of the final manuscript. All authors contributed to and have approved the final manuscript.

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