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ORIGINAL INVESTIGATION

Implicit attitudes towards smoking predict long-term relapse in abstinent smokers

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Abstract

Rationale It has previously been argued that implicit attitudes toward substance-related cues drive addictive behavior. Nevertheless, it remains an open question whether behavioral markers of implicit attitude activation can be used to predict long-term relapse.

Objectives The main objective of this study was to examine the relationship between implicit attitudes toward smoking-related cues and long-term relapse in abstaining smokers.

Methods Implicit attitudes toward smoking-related cues were assessed by means of the Implicit Association Test (IAT) and the evaluative priming task (EPT). Both measures were completed by a group of smokers who volunteered to quit smoking (patient group) and a group of nonsmokers (control group). Participants in the patient group completed these measures twice: once prior to smoking cessation and once after smoking cessation. Relapse was assessed by means of short telephone survey, 6 months after completion of the second test session.

Results EPT scores obtained prior to smoking cessation were related to long-term relapse and correlated with self-reported nicotine dependence as well as daily cigarette consumption. In contrast, none of the behavioral outcome measures were found to correlate with the IAT scores.

Conclusions These findings corroborate the idea that implicit attitudes toward substance-related cues are critically involved in long-term relapse. A potential explanation for the divergent findings obtained with the IAT and EPT is provided.

Keywords Implicit attitudes · Evaluative priming · Implicit association · Nicotine · Relapse · Picture-picture naming task · Extra-personal associations

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Relapse in abstaining substance-dependent patients is typically (very) high (e.g., Moos and Moos 2006; Sheffer et al. 2012). It should therefore come as no surprise that addiction researchers have invested a great deal of effort in identifying the psychological processes that bring about renewed drug use after successful treatment. If anything, this line of research has shown that drug relapse is caused by a complex interplay of various factors, including interindividual differences in coping strategies (e.g., Gossop et al. 2002), impulsiveness (e.g., Fox et al. 2010), the propensity to delay reward (e.g., Sheffer et al. 2012), attentional bias to substance-related cues (e.g., Powell et al. 2010), working memory capacity (e.g., Patterson et al. 2010), and craving (e.g., Wise 1988).

There is also evidence showing that relapse is dependent upon automatically activated attitudes toward substance-related cues (hereafter referred to as *implicit attitudes*, see De Houwer et al. 2009). As an example, consider the findings of Marhe et al. (2013), who used the Implicit Association Test (hereafter referred to as *IAT*; see Greenwald et al. 1998) to capture implicit attitudes toward heroin and cocaine in

abstaining drug-dependent patients. Results showed that IAT scores obtained during episodes of increased temptation (in contrast to IAT scores obtained at randomly selected moments) were much more positive in drug-dependent patients who relapsed within 9 days of treatment as compared to patients who remained abstinent. This finding is further corroborated by a large number of nonclinical studies in which measures of implicit attitudes toward drugs were found to correlate with various aspects of addictive behavior (for a meta-analysis, see Rooke et al. 2008). In the context of alcohol addiction, for example, Wiers and colleagues demonstrated repeatedly that an IAT measure of the implicit attitude toward alcohol correlates with self-reported alcohol use (e.g., Houben et al. 2010b; Wiers et al. 2002). Likewise, Descheemaeker et al. (2014) were able to predict beer consumption during a bogus taste test on the basis of the implicit attitude toward beer as measured by the evaluative priming task (hereafter referred to as *EPT*, see Fazio et al. 1995).

The observation that implicit attitudes toward substance-related stimuli can drive addictive behavior is in line with recent two-process models of addiction (e.g., Deutsch and Strack 2006; Strack and Deutsch 2004; Wiers and Stracy 2006). According to these models, addictive behavior is governed by two semi-independent systems: an "impulsive system," in which the affective-motivational significance of substance-related stimuli and associated behavioral schemata become activated in an automatic fashion, and a "reflective system" in which knowledge about the values and probabilities of different behavioral consequences is weighed and integrated in a nonautomatic fashion. Crucially, the operating conditions of both systems are assumed to be quite different. Whereas the operation of the reflective system is assumed to require a high amount of cognitive capacity, the opposite is true for the impulsive system (Strack and Deutsch 2004). Two-process models of addiction therefore predict that the impulsive system will exert primary control over behavior under conditions of reduced motivation and/or opportunity to engage in reflective processing (see also Fazio and Towles-Schwen 1999). Crucially, the capacity to engage in reflective processing is assumed to vary as a function stable differences between individuals (e.g., Farris et al. 2010; Lindgren et al. 2014; Thush et al. 2008; Spruyt et al. 2013; but see Pieters et al. 2012) as well as temporary factors such as cognitive load, fatigue, and stress (Wiers et al. 2010). Accordingly, two-process models of addiction can readily explain the observations that (a) it is difficult to abstain from substance abuse and (b) relapse rates in abstaining patients are typically very high.

Nevertheless, only a few attempts have been made to document the relationship between implicit attitudes toward drug-related cues and relapse to dependence. Moreover, in each of these studies, relapse was monitored during a relatively brief follow-up period (e.g., Marhe et al. 2013). It thus remains an open question whether measures of implicit attitudes toward substance-related cues can be useful to predict long-term relapse in abstaining substance-dependent patients. To shed light on this issue, we examined implicit attitudes toward smoking-related cues in a large sample of smokers who had already signed up for participation in a smoking cessation program (hereafter referred to as the *patient group*). Both the IAT and the EPT were used to capture the implicit attitude toward smoking. We asked participants to complete the implicit attitude measures immediately following the first session of the smoking cessation program (i.e., prior to their attempt to quit smoking). Smokers who actually managed to quit smoking were asked to complete the implicit attitude measures for a second time between 4 and 8 days after smoking cessation. Six months later, relapse was assessed by means of short telephone survey.

Although the relationship between relapse and measures of implicit attitude activation toward smoking was the prime focus of the present study, we also wanted to address a number of additional research questions. First, we wanted to compare the predictive validity and reliability of the IAT and EPT. Although both measures are referred to as "implicit attitude measures," the underlying mechanisms that drive performance in these tasks are known to be quite different (see Conrey et al. 2005; Klauer et al. 2007; Spruyt et al. 2007c). Unlike the EPT, for example, the IAT is sensitive to salience asymmetries (e.g., Rothermund and Wentura 2004), recoding processes (e.g., Rothermund et al. 2009), and automatically activated extra-personal associations (Karpinski and Hilton 2001). In addition, it has been argued that the EPT allows for a measurement of implicit attitudes at the exemplar level (i.e., the individual stimuli that are used in the task), whereas the IAT is more suited to capture implicit attitudes at a category level (De Houwer et al. 2009). It is therefore important to compare the added value of the IAT and the EPT directly, an endeavor that has yet to be undertaken in the context of addiction in general and relapse in particular.

Second, we wanted to examine whether the predictive validity of implicit attitude measures is dependent upon attentional control. Several studies have shown that substance-dependent patients are characterized by an attentional orienting response toward drug-related stimuli (Fadardi and Cox 2009; Field and Cox 2008; Townshend and Duka 2001). We therefore reasoned that the implicit attitude toward smoking may be more likely to affect addictive behavior in persons who have difficulty controlling the attention-grabbing power of smoking-related stimuli (Wiers et al. 2010; Farris et al. 2010). The more a smoker tends to attend to smoking-related stimuli, the more likely this person will be influenced by his/her implicit attitude toward those stimuli. Accordingly, we also administered the Attentional Control Scale (hereafter referred to as *ACS*), a measure of individual differences in the ability to focus perceptual attention, switch attention between

tasks, and flexibly control thought (Derryberry 2002; Derryberry and Reed 2002). In line with Farris et al. (2010), we expected the predictive validity of the IAT and the EPT to be more pronounced in abstaining nicotine-dependent patients who score low on the ACS than in nicotine-dependent patients who score high on the ACS (see also Wiers et al. 2010).

Finally, we wanted to examine whether smokers who are committed to quit smoking exhibit different implicit attitudes toward smoking-related cues as compared to nonsmokers. Whereas previous research has invested a great deal of effort in comparing implicit attitudes toward smoking-related cues in smokers and nonsmokers (e.g., Payne et al. 2007; Swanson et al. 2001), very little is known about implicit attitudes toward smoking-related cues in the subgroup of smokers who are committed to quit smoking. There are some reasons to suspect, however, that implicit attitudes toward smoking-related cues might be quite negative in individuals who are committed to abstinence. In the context of alcohol addiction, for example, Spruyt et al. (2013) demonstrated that abstaining alcohol-dependent patients are characterized by a strong automatic tendency to avoid alcohol-related cues. Likewise, Noel et al. (2006) observed that abstaining alcohol-dependent patients can develop an attentional bias away from alcohol-related stimuli. It might thus be hypothesized that smokers who are committed to abstinence might exhibit a more negative implicit attitude toward smoking-related cues as compared to nonsmokers. To verify this prediction, we assessed implicit attitudes toward smoking-related stimuli both in a sample of smokers who were committed to quit smoking and a sample of 30 nonsmokers (hereafter referred to as the *control group*).

Method

Participants and design

Participants were a convenience sample of 78 smokers (48 men) and 30 controls (13 men). Participants from the patient group were either recruited at the smoking cessation clinic of Gasthuisberg University Hospital, Leuven, Belgium (n=57) or Ghent University Hospital, Ghent, Belgium (n=21). They were asked to participate after they had already volunteered to enter a smoking cessation program and were offered 30 € in exchange for their participation. Payment was contingent, however, upon completion of two test sessions: once prior to smoking cessation and once after smoking cessation. At the first test session, participants in the patient group reported to smoke, on average, 20.26 cigarettes each day (SE=1.27).

At both sites, the smoking cessation program consisted of a mixture of medical and cognitive-behavioral interventions. The time taken between the first test session and actual smoking cessation was 39.87 days (SE=6.26 days). The

second test session was completed between 4 and 8 days after smoking cessation. In total, 37 participants did not complete the second test session. The sample size of the patient group at the second test session was thus 41. Participants dropped out from the study for various reasons. While some participants reported that they were simply unable to quit smoking, others did not return for the second test session because they were hospitalized or found it too time-consuming to participate. In most cases, however, participants simply stopped attending the smoking cessation sessions at some point in time without any explanation. In sum, the group of participants who dropped out from the study was quite heterogenic.

Within the final sample of 41 abstaining patients, relapse was assessed by means of a short telephone survey that was scheduled to take place 6 months after the second test session. Nevertheless, relapse data of two participants were obtained long after the anticipated follow-up period of 180 days had elapsed (i.e., 351 and 358 vs. 188 days in the remaining sample), despite numerous attempts to contact these participants in due time. We therefore excluded the data of these participants from the analyses of the relapse data. Note, however, that none of the reported results are critically dependent upon on the inclusion or exclusion of these participants.

Participants in the control group had never smoked and were recruited from the network of acquaintances of two research assistants. They were not paid for their participation. The patient group and the control group were matched for age (M_{age}=52.60 and M_{age}=52.67, respectively) but not for other variables such as socioeconomic status. Some caution is thus in order when interpreting the results of between-group comparisons. All participants gave their informed consent before participating. The study was approved by the Ethics Committees of Gent University Hospital and Gasthuisberg University Hospital.

Apparatus and measures

Apparatus A standard portable computer was used to administer the implicit attitude measures. All stimuli were presented against a black background of an external LCD (19 in. 1024× 768 pixels). An Affect 4.0 program (Spruyt et al. 2010) controlled the presentation of the stimuli as well as the registration of the response latencies. An external voice key that was connected to the parallel port of the portable computer was used to measure response latencies during the EPT.

Evaluative priming task In a typical evaluative priming task, participants are asked to respond to a series of target stimuli that have a clear evaluative meaning. Each target is preceded by a prime. If a particular person is faster to respond to positive target stimuli than to negative target stimuli after the presentation of a particular prime stimulus, one can infer that this person holds a positive implicit attitude toward this prime

stimulus. Conversely, if a person is faster to respond to negative target stimuli as compared to positive target stimuli after the presentation of a particular prime stimulus, one can infer that this person holds a negative implicit attitude toward this prime stimulus (e.g., Fazio et al. 1995).

The stimuli that were used as primes in the present study were five pictures related to smoking (e.g., a person holding a cigarette), five pictures unrelated to smoking (e.g., a person holding a pencil), and five neutral stimuli (i.e., geometrical figures presented on a blue background). Target stimuli were five positive pictures (i.e., a baby, a bride, a dolphin, a kitten, and a teddy bear) and five negative pictures (i.e., a gun, a corpse, an explosion, a skull, and a bunch of worms). All pictures were 512 pixels wide and 384 pixels high. Target pictures were selected on the basis of norm data collected by Spruyt et al. (2002). The difference between the mean valence ratings of positive ($M=3.37$, $SD=0.47$) and negative target pictures ($M=-2.77$, $SD=0.83$) was statistically reliable, $t(8)=12.05$, $p<.0001$. Following the procedures described by Spruyt et al. (2007b), participants were asked to name the target pictures as fast as possible with a single word (see also Vandromme et al. 2011; Verhulst et al. 2006).

Each possible prime-target combination was presented once, resulting in 150 evaluative priming trials. Each trial started with a 500-ms presentation of a fixation cross. Next, after an inter-stimulus interval of 500 ms, the prime was presented for 200 ms. Finally, 50 ms after the offset of the prime, the target was presented until the participant gave a response, resulting in a stimulus onset asynchrony (SOA) of 250 ms. The experimenter coded whether the microphone was accurately triggered and whether the participant's response was correct by pressing one of three keys on the computer keyboard. After the experimenter entered the code, the next trial was initiated after a time interval that varied randomly between 500 and 1500 ms.

Preceding the evaluative priming task, participants completed two series of practice trials. In the first practice phase, each target picture was presented once in a self-paced, random sequence (i.e., 10 trials). The correct naming response was presented underneath each target picture and participants were asked to memorize the pictures-word combinations. In the second practice phase, the target stimuli were again presented in a random sequence (i.e., 10 trials). Participants were asked to name the target pictures using the words that were learned during the first practice phase. Each target was presented until a naming response was registered.

Implicit association test In a typical IAT, participants are asked to categorize stimuli into four different stimulus categories by pressing one of two response keys. The core idea underlying the IAT is that categorization performance should be better when categories that are associated in memory are assigned to the same response key. Hence, by examining which response assignments result in the best categorization performance, one can determine which stimulus categories are more closely associated in memory.

In the present study, the following categories were used: positive words (i.e., good, happy, pleasant, friendly, sympathetic), negative words (i.e., annoying, cruel, angry, false, unpleasant), pictures related to smoking, and pictures unrelated to smoking. The pictures used in the IAT were the same as those used in the EPT. All words were presented in white (font Arial, font size 28). Participants first completed two practice phases, one in which the words were to be categorized on the basis of their evaluative meaning (i.e., 20 trials, each stimulus presented twice) and one in which the pictures were to be categorized in terms of their relatedness to smoking (i.e., 20 trials, each stimulus presented twice). Whereas negative and positive stimuli were always assigned to the left and the right response key, respectively, response assignments were counterbalanced across participants for the pictorial stimuli. Half of the participants were asked to use the left and the right key to respond to smoking-related and smoking-unrelated pictures, respectively. The remaining participants were asked to use the reversed response assignment. Next, participants completed a first block of critical test trials in which all stimuli were presented three times (i.e., 60 trials in total). Participants were asked to use the same response assignments as those used in the preceding practice phases. Following the first test block, participants were again presented with a practice block in which smoking-related and smoking-unrelated pictures were to be categorized in terms of their relatedness to smoking (i.e., 30 trials, each stimulus presented three times). Crucially, the response assignments were reversed. Finally, participants completed a second test block in which all stimuli were presented three times (i.e., 60 trials in total). The standard response assignment for the word stimuli was now combined with the reversed response assignment for the pictorial stimuli. In all phases, the relevant response labels were presented in the upper left and right corner of the computer screen (upper case, font Arial, font size 28).

The specific version of the EPT that was used in the present research is known to be sensitive to variations in the extent to which participants adopt an explicit evaluative processing goal (Spruyt 2014; Spruyt et al. 2012, 2009, 2007a). Therefore, given that the IAT involves explicit evaluative judgments, the EPT was always administered first. After completion of the EPT and the IAT, participants were asked to complete a series of self-report measures.

Self-report measures The Fagerstrom Test for nicotine dependence (hereafter referred to as FTND) was used to measure nicotine dependency (Heatherton et al. 1991). The ACS was used to measure individual differences in the ability to focus perceptual attention, switch attention between tasks, and flexibly control thought (e.g., Derryberry and Reed 2002). The internal consistency of the ACS was acceptable (Cronbach's

$\alpha=.77$). On average, participants in the patient group ($M=54.13$) exhibited the same degree of attentional control as participants in the control group ($M=52.57$), $t<1$. Finally, participants were asked to provide explicit valence ratings of cigarettes using two separate 10-point scales for pleasantness and unpleasantness. Each scale ranged from 1 ("not true") to 10 ("true"). For each participant, we subtracted the unpleasantness rating from the pleasantness rating to obtain a single explicit valence measure.

Results

Data reduction

For each participant and each test session, we calculated an implicit attitude score on the basis of the EPT data. In line with the procedures described by Spruyt et al. (2007b), we calculated two difference scores. First, we subtracted the mean response latencies observed on trials consisting of a smoking-related prime and a positive target from the mean response latencies observed on trials consisting of a smoking-related prime and a negative target. This difference score could, however, be biased by differences in the extent to which participants are generally faster or slower to respond to positive targets as compared to negative targets, irrespective of the nature of the preceding prime stimulus. We therefore calculated a second difference score by subtracting the mean response latencies observed on trials consisting of a neutral prime and a positive target from mean response latencies observed on trials consisting of a neutral prime and a negative target. Finally, the EPT score was obtained by subtracting the second difference score from the first difference score. The higher the EPT score, the more positive the implicit attitude toward smoking. Mean response latencies were computed after exclusion of trials on which an incorrect response (test session 1: 3.17 %, test session 2: 4.45 %), an erroneous voice key trigger (test session 1: 4.09 %, test session 2: 6.34 %), or a far-out value (test session 1: 7.50 %, test session 2: 5.38 %) was registered. Outliers were defined as response latencies that were smaller than 150 ms or larger than 1000 ms (Ratcliff 1993). Prior to outlier exclusion, the overall mean response latency was 729 ms during the first test session. During the second test session, the overall mean response latency was 669 ms.

Individual IAT scores were obtained using the D-600 scoring algorithm described by Greenwald et al. (2003). Accordingly, all trials with latencies larger than 10,000 ms were eliminated (test session 1: 0.28 %, test session 2: 0.08 %). The proportion of trials with a response latency below 300 ms was quite low (test session 1: 0.10 %, test session 2: 0.00 %) and never exceeded the 10-% cutoff point for an individual participant. On average, it took participants 1147 ms to respond during the first test session. During the second test session, the overall mean response latency was 1037 ms. The test block in which smoking-related stimuli and negative stimuli were assigned to the same key was defined as the incompatible block. The test block in which smoking-related stimuli and positive stimuli were assigned to the same key was defined as the compatible block. Positive IAT scores thus reflect a positive implicit attitude toward smoking.

Attitudes at the group level: differences between groups prior to smoking cessation

We first examined the explicit attitude ratings. Whereas participants in the control group reported, on average, a strong negative attitude toward cigarettes, $M=-8.00$, $SD=2.21$, $t(29)=-19.80$, $p<.001$, participants in the patient group reported a mild (but nonsignificant) positive attitude toward cigarettes, $M=0.95$, $SD=5.01$, $t(77)=1.67$, $p=.10$. The difference between both groups was statistically reliable, $t(103.92)=12.85$, $p<.00001$.[1]

The results obtained with the EPT were more or less in line with this data pattern. Whereas participants in the control group exhibited a strong negative implicit attitude toward smoking, $M=-25$ ms, $SD=44$ ms, $t(29)=3.05$, $p<.005$, participants in the patient group exhibited, on average, no implicit preference at all, $M=0$ ms, $SD=46$ ms, $t<1$. The difference between both groups was again reliable, $t(106)=2.49$, $p<.05$.

The results obtained with the IAT showed a completely different data pattern. The mean IAT score obtained in the patient group was significantly smaller than zero, $M=-.37$, $SD=.50$, $t(77)=-6.55$, $p<.00001$, suggesting a (strong) negative implicit attitude toward smoking. The mean IAT score obtained in the control group was also negative, albeit not significantly so, $M=-.15$, $SD=.58$, $t(29)=-1.39$, $p=.17$. In fact, the negative implicit attitude toward smoking as measured by the IAT was much more pronounced in the patient group as compared to the control group, $t(106)=2.00$, $p<.05$.

We also examined whether implicit and explicit attitudes toward smoking were different in patients who did ($n=37$) and did not drop out ($n=41$) before the second test session took place. Reassuringly, none of these comparisons approached significance, all ts<1.04, all ps$>.30$. Both groups of smokers were also comparable in terms of attentional control (ACS), daily cigarette consumption, and self-reported nicotine dependence (FTND), all ts<1.37, all ps$>.17$.

Attitudes at the group level: differences between test sessions

Prior to smoking cessation, the mean explicit attitude toward cigarettes was mildly positive in participants who completed

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[1] The Welch-Satterthwaite approximation method was used to compensate for the violation of the equality-of-variances assumption.

both test sessions, $M=1.17$, $SD=5.40$, $t(40)=1.39$, $p=.17$. After smoking cessation, the same group of participants reported a strong negative attitude toward cigarettes, $M=-2.97$, $SD=5.40$, $t(40)=-3.53$, $p<.005$. The difference between both test sessions was highly significant, $t(40)=5.44$, $p<.001$.

In line with this observation, the IAT data also suggest that smoke-related cues became more negative from the first to the second test session. Participants who completed both test sessions displayed a strong negative IAT score prior to smoking cessation, $M=-.43$, $SD=.40$, $t(40)=6.79$, $p<.001$, that became even more negative after smoking cessation, $M=-.54$, $SD=.54$, $t(40)=6.36$, $p<.001$. However, the difference between both test sessions was far from significant, $t(40)=1.32$, $p=.20$.

In contrast, there was no evidence whatsoever that implicit attitudes toward smoking as measured by the EPT changed over time. Both at the first ($M=3$ ms, $SD=44$ ms) and the second test session ($M=1$ ms, $SD=39$ ms), the mean EPT score was virtually zero, $t<1$.

Attitudes at the individual level: correlations between different measures, test-retest reliabilities, and internal consistencies

Both prior to smoking cessation (test session 1) and after smoking cessation (test session 2), all correlations between the explicit attitude measure, the EPT, and the IAT were non-significant (see Table 1). Nevertheless, significant test-retest correlations were obtained for both the IAT and the explicit attitude measure. The test-retest correlation of the EPT was unreliable. Finally, we examined the internal consistency of the two implicit attitude measures. In line with earlier reports (e.g., Greenwald and Nosek 2001), the internal consistency of the IAT was quite high, both at the first test session (Cronbach's $\alpha=.87$) and the second test session (Cronbach's $\alpha=.89$). Also in line with earlier reports (e.g., Bosson et al. 2000), the internal consistency of EPT was considerably lower. For the first test session, the internal consistency of the EPT was still acceptable (i.e., Cronbach's $\alpha=.75$). For the second test session, however, the internal consistency of the EPT was substandard (Cronbach's $\alpha=.18$).[2]

Attitudes and behavior: relationship between attitude measures obtained prior to smoking cessation (test session 1), smoking behavior, and relapse

We first examined whether the (implicit and explicit) attitude measures correlated with (a) self-reported smoking behavior (i.e., daily cigarette consumption), (b) nicotine dependency (i.e., FTND), and (c) the time taken to quit smoking. As can be seen in Table 2, both the explicit attitude measure and the IAT failed to correlate with each of these behavioral measures. In contrast, the EPT scores correlated positively with self-reported nicotine dependence as well as the number of

cigarettes that participants reported smoking each day. The correlation between the EPT scores and the number of days taken to quit smoking was not significant.

Next, we examined the extent to which the attitude measures were related to relapse. In total, 18 patients (46.15 %) relapsed within 6 months. Univariate logistic regression analyses revealed no evidence whatsoever for the existence of a meaningful relationship between relapse and individual differences in the self-reported attitude toward cigarettes, $\chi^2<1$ (56.4 % correct classifications). Likewise, relapse was unrelated to individual differences in the implicit attitude toward smoking as measured by the IAT, $\chi^2<1$ (56.4 % correct classifications). A significant relationship was found, however, between relapse and individual differences in the implicit attitude toward smoking as measured by the EPT, $\chi^2(1)=4.59$, $p<.05$, Nagelkerke $R^2=.15$, $OR=1.018$ (69.2 % correct classifications). The more positive the EPT score, the higher the chance to relapse within 6 months. In line with this observation, the mean EPT score obtained in patients who relapsed ($M=21$ ms) was clearly different from the mean EPT score obtained in patients who remained abstinent ($M=-9$ ms), $t(37)=2.13$, $p<.05$.

To examine whether the EPT scores were predictive of relapse over and above other predictors, we first examined whether relapse was related to age, gender, self-reported nicotine dependence (i.e., FTND score), daily cigarette consumption, and the time needed to actually quit smoking. Only one of these variables proved to be a valid predictor of relapse, i.e., the time needed to actually quit smoking, $\chi^2(1)=7.96$, $p<.01$, Nagelkerke $R^2=.25$, $OR=1.030$ (66.7 % correct classifications). The predictive validity of all the other variables was far from significant (χ^2s<1.25, ps$>.27$). Next, we examined whether the EPT scores were predictive of relapse over and above the time needed to actually quit smoking. Adding the EPT scores as a predictor, resulted in a significantly better model fit, $\chi^2(1)=5.00$, $p<.05$, Nagelkerke $R^2=.38$, $OR=1.021$. On the basis of this model, 71.8 % of all cases were classified correctly.

Finally, we examined whether the predictive validity of the implicit attitude measures was dependent upon attentional control (ACS). To that end, we performed two additional logistic regression analyses, one for the IAT and one for the EPT, in which the implicit attitude measure, the (continuous) ACS scores, and the interaction term were used as predictors. For

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[2] For the IAT, Cronbach α's were computed on the basis of five different IAT scores. In line with earlier work by Teige-Mocigemba et al. (2008), each test block was divided into five sequential subblocks, and an IAT score was computed for each pair of subblocks. Cronbach α's for the EPT were also computed on the basis of five different EPT scores, one for each smoke-related prime stimulus. Each of these EPT scores was computed as described in the "Data reduction" section, with the exception that we only included smoke-related trials on which a specific smoke-related stimulus was presented.

Table 1 Attitude measures: correlations and test-retest reliability

Attitude measure	Prior to smoking cessation			After smoking cessation			Test-retest
	1	2	3	1	2	3	
1. Explicit attitude	1			1			.59**
2. Evaluative priming task	.03	1		.10	1		−.25
3. Implicit Association Test	−.15	.07	1	−.14	−.03	1	.40*

*$p<.01$; **$p<.001$

the EPT data, the interaction term was reliable, Wald=4.09, $p<.05$, OR=.995. In line with our expectations, follow-up analyses confirmed that the EPT scores were predictive of relapse in participants low in attentional control (i.e., ACS score≤56, $n=$ 20), $\chi^2(1)=6.49$, $p<.05$, Nagelkerke $R^2=.41$ (90.0 % correct classifications). In contrast, participants high in attentional control (i.e., ACS score>56, $n=19$) exhibited no evidence whatsoever for the existence of a meaningful relationship between the EPT scores and relapse, $\chi^2<1$ (63.2 % correct classifications). A similar analysis for the IAT data confirmed that the IAT scores were unrelated to relapse, both in participants who exhibited a high degree of attentional control, $\chi^2<1$, and in participants who exhibited a low degree of attentional control, $\chi^2< 1$. Accordingly, the interaction between the ACS scores and the IAT was far from significant, Wald=1.48, $p>.22$. The correlation between the ACS and the implicit attitude measures was unreliable at both test moments (all $|r|<.15$, all $p>.23$).

Attitudes and behavior: relationship between attitude measures obtained after smoking cessation (test session 2), smoking behavior, and relapse

All the analyses reported above were repeated using the attitudes measures obtained after smoking cessation. As can be

Table 2 Correlations between smoking behavior and attitude measures

Attitude measure	Nicotine dependence	No. of cigarettes	No. of days
Attitude measures obtained prior to smoking cessation ($N=78$)			
Explicit attitude	.14	.07	.21
Evaluative priming task	.26*	.34**	.03
Implicit Association Test	.08	−.10	.12
Attitude measures obtained after smoking cessation ($N=41$)			
Explicit attitude	−.11	−.13	.20
Evaluative priming task	.07	.04	.01
Implicit Association Test	−.13	−.27†	−.05

No. of cigarettes daily cigarette consumption, *No. of days* number of days between the start of the smoking cessation program and actual smoking cessation

**$p<.005$; *$p<.05$; †$p<.10$

seen in Table 2, none of the correlations between the attitude measures and (various aspects of) smoking behavior were statistically reliable. Likewise, none of the attitude measures were related to relapse. Virtually, all effects involving either the EPT or the IAT were associated with a Wald statistic smaller than 1.32 ($ps>.25$). The only exception was the interaction between the IAT and the (continuous) ACS scores, Wald= 3.83, $p=.05$, OR=.788. Follow-up analyses revealed, however, that the relationship between the IAT and relapse was unreliable both in participants high in attentional control, Wald= 1.38, $p=.24$, OR=.255, and in participants low in attentional control, Wald<1. We are therefore reluctant to give much weight to this isolated finding.

Attitudes and behavior: relationship between relapse and changes in attitude measures

Finally, we examined whether relapse was dependent upon the extent to which implicit and explicit attitudes toward smoking-related cues changed from the first to the second test session. Both for the explicit attitude ratings and the IAT scores, this relationship was unreliable, both $\chi^2s<1$. In contrast, changes in the EPT scores did correlate with relapse, $\chi^2(1)=4.04$, $p<.05$, Nagelkerke $R^2=.13$, OR=1.011 (71.8 % correct classifications). In all likelihood, however, this finding resulted from the fact that (a) the EPT scores obtained at the first test session were reliable and related to relapse, whereas (b) the EPT scores obtained at the second test session were completely unreliable (see above). We are therefore reluctant to give much weight to this finding.

Discussion

In line with two-process models of addiction (e.g., Deutsch and Strack 2006; Strack and Deutsch 2004; Wiers and Stracy 2006), there is now ample evidence showing that automatic processes play a critical role in addiction. Substance-related stimuli have been shown to automatically (a) grab the user's attention (e.g., Field and Cox 2008), (b) activate approach/avoidance tendencies (e.g., Eberl et al. 2013; Spruyt et al. 2013; Wiers et al. 2011), and (c) activate implicit attitudes from memory (e.g., Houben et al. 2010c; Wiers et al. 2002). Nevertheless, only a

limited number of studies have documented the extent to which these automatic processes drive relapse in abstaining patients.

In the present study, we examined whether implicit attitude measures as measured by the IAT and the EPT can be used to predict long-term relapse in abstaining nicotine-dependent patients. Our findings clearly indicate that implicit attitude scores obtained with (an adapted version of) the EPT (see Spruyt et al. 2007b) are indeed predictive of relapse over a 6-month follow-up period. In line with our expectations, relapse rates were higher among participants who, prior to smoking cessation, exhibited a more positive implicit attitude toward smoking as compared to participants who exhibited a more negative implicit attitude toward smoking. Moreover, the EPT scores were found to predict relapse over and above other predictors such as the time taken to quit smoking and daily cigarette consumption. Taken together, these findings strongly suggest that the EPT can be used as a unique and powerful tool to predict addictive behavior, a conclusion that is further corroborated by two additional observations. First, the EPT scores were found to correlate with nicotine dependence (FTND) as well as daily cigarette consumption. Second, the EPT scores also discriminated between smokers and non-smokers: In line with earlier reports (e.g., Payne et al. 2007), the mean EPT score was significantly more negative in the control group than in the patient group.

Interestingly, the observed relationship between the EPT scores obtained prior to smoking cessation and relapse was contingent upon participants' level of attentional control. That is, the predictive validity of the EPT scores was much more pronounced in participants who exhibited a low degree of attentional control (i.e., 90.0 % correct classifications) as compared to participants who exhibited a high degree of attentional control (i.e., 63.2 % correct classifications). This data pattern is clearly in line with the idea that implicit attitudes toward drug-related cues are more likely to affect addictive behavior in participants who have difficulty controlling the attention-grabbing power of smoking-related stimuli (Farris et al. 2010; Wiers et al. 2010). It might thus be worthwhile to develop intervention strategies that target an individual's level of attentional control rather than his/her implicit attitudes toward drug-related cues per se. As an alternative explanation, however, it might also be argued that the EPT is simply unable to capture implicit attitudes in participants who are characterized by a high degree of attentional control. Irrespectively, the observation that the predictive validity of the EPT was contingent upon attentional control suggests that measures of attentional control may be used to identify individuals for whom the EPT data are likely to predict behavior. Put differently, it may be possible to discriminate between individuals for whom the task "works" and individuals for whom the task "doesn't work." Given that the overall predictive validity of the EPT is still far from perfect, such an approach seems particularly fruitful from an applied point of view.

It should be noted, however, that the predictive validity of the EPT scores was confined to data that were gathered prior to smoking cessation. An analysis of the internal consistency of the EPT scores suggests at least one explanation for this finding. Whereas the internal consistency of the EPT was quite good for data collected during the first test session (Cronbach's $\alpha=.75$), it was simply substandard for data collected during the second test session (Cronbach's $\alpha=.18$). For the same reason, it is also difficult to interpret the observations that (a) the EPT scores did not change from the first to the second test session and (b) that the EPT scores obtained after smoking cessation were unrelated to (various aspects of) smoking behavior. Very little is known, however, about the extent to which prior experience with the EPT can affect task performance in subsequent test sessions. Additional research would therefore be needed to explain why exactly the reliability of the EPT scores dropped from the first to the second test session.

A final point of discussion concerns the results obtained with the IAT. Unlike Marhe et al. (2013), we found no evidence for the existence of a meaningful relationship between implicit attitudes as measured by the IAT and relapse. The IAT scores also failed to correlate with other (behavioral) measures of nicotine addiction. This discrepancy can be accounted for in a number of ways. First, whereas Marhe et al. (2013) looked at relapse within a window of just 9 days, the follow-up period in the present study spanned (about) 6 months. It could thus be hypothesized that a significant relationship between the IAT scores and relapse may have been found had we assessed relapse at an earlier time. Second, and probably more importantly, Marhe et al. (2013) reported that their IAT measure was predictive of relapse only when the IAT was administered during an episode of increased temptation. In our study, however, participants were always tested at predetermined moments. It was thus a matter of chance whether participants experienced increased temptation at the time of testing. If this is a prerequisite for IAT to produce valid implicit attitude scores in the context of addiction, the null findings that were obtained with the IAT are anything but surprising. Finally, it might simply be argued that the poor (predictive) validity of the IAT scores resulted from the fact that the IAT was always administered after participants had already completed the EPT. As explained above, we deliberately opted for this strategy because the specific version of the EPT that was used in the present research is known to be sensitive to variations in the extent to which participants adopt an explicit evaluative processing goal. Therefore, given that the IAT involves explicit evaluative judgments, we had no other option but to use a fixed task order. As a consequence, however, one might argue that participants were already fatigued or bored by the time they were asked to complete the IAT.

Still, it remains a remarkable observation that we failed to predict behavior on the basis of the IAT scores whilst their reliability was more than acceptable. In this respect, it is important to emphasize that the IAT revealed a strong negative

attitude toward smoking in the patient group. In fact, the negative implicit attitude toward smoking as measured by the IAT (a) was more pronounced in the patient group than in the control group and (b) even tended to become more negative from the first to the second test session. While the interpretation of the latter finding is complicated by the fact that a proper control condition is missing, these observations seem to suggest that the IAT was either influenced by automatically activated extra-personal associations (i.e., knowledge about the fact that smoking is generally viewed as negative in Western societies; see Karpinski and Hilton 2001) or by automatically activated (but personally endorsed) propositional knowledge about the negative consequences of smoking (see Hughes et al. 2011). Interestingly, this interpretation would coincide with findings obtained by Chassin et al. (2010). In line with our observations, these authors found the average IAT score in smokers to be negative rather than positive (see also Swanson et al. 2001). Moreover, Chassin et al. (2010) observed that smokers were more likely to quit smoking as the IAT revealed a more negative attitude toward smoking. Given that attempts to quit smoking must be driven by personally endorsed health concerns and (negative) societal views of smoking behavior, it seems logical that an implicit measure that captures this type of information can be used to predict smoking cessation attempts. At the same time, however, our findings indicate that such a measure may be unsuited to predict relapse in smokers who do manage to quit smoking. For that purpose, the EPT is clearly better suited. It should be noted, however, that new variants of the IAT have been developed that are known to control for the influence of factors such as extra-personal associations (e.g., the personalized IAT; see Olson and Fazio 2004). It could thus be worthwhile to examine the predictive validity of these new generation of IAT measures in future addiction research.

In sum, the present findings strongly suggest that implicit attitudes toward drug-related cues are critically involved in long-term relapse. It thus seems worthwhile (a) to take these implicit attitudes into account when trying to predict relapse and (b) to further scrutinize the usefulness of treatment strategies that target these implicit attitudes directly (e.g., Houben et al. 2010a).

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