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Implicit Attitudes to Smoking are Associated with Craving and Dependence

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Abstract

The Implicit Association Test (IAT) has been used to assess automatic affective responses to drug cues. Smokers (N = 57) completed the IAT at four experimental sessions. They abstained from smoking before two of the sessions (AB), and smoked normally before the other two sessions (NON). At one AB (and NON) session, they smoked a cigarette about 40 minutes before completing the IAT (S), and at the other they did not smoke (NS). Overall, participants exhibited a negative IAT effect, indicating that they found the classification task easier when smoking was paired with bad than when smoking was paired with good. Using repeated measures ANOVA, the IAT effect was made less negative by pre-session Abstinence, and made more negative by Smoking. It was most negative in the NON-S condition. Using Generalized Estimating Equations analyses, the IAT effect was positively associated with pre-task craving ratings assessed on the Questionnaire of Smoking Urges-Brief, but was not associated with a physiological measure of automatic affective responses (startles while viewing smoking vs. neutral pictures). The IAT effect was associated with scores on the Fagerstrom Test for Nicotine Dependence. In sum, automatic affective responses assessed with the smoking IAT are associated with measures of smoking motivation and dependence.

Keywords

Implicit Association Test; Startle; Craving; Dependence

1. Introduction

A fundamental distinction was drawn in cognitive psychology between automatic and non-automatic psychological processes (e.g., Shiffrin and Schneider, 1977), and an understanding of automatic processes continues to be a central concern in many areas of cognitive and social psychology. More recently, automaticity has been viewed as a continuum rather than a dichotomy (e.g., Logan, 1985), with some processes being more automatic than others (Moors and de Houwer, 2006). Relatively automatic processes are

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characterized by the presence of one or more features, including being fast, efficient, effortless, stimulus-driven, uncontrolled, and unconscious (Moors and de Houwer, 2006). These (relatively) automatic processes can be difficult to assess with self-report measures, but can be captured through responses on speeded reaction time tasks.

Much recent research on the psychological processes underlying tobacco addiction has focused on the measurement of automatic cognitive processes using speeded reaction time tasks (Waters and Sayette, 2005). Measures of automatic cognitive processes may explain some of the variation in addictive behavior beyond that accounted for by measures of controlled processes (e.g., Wiers et al., 2002). The Implicit Association Test (IAT) is a widely used task for investigating automatic affective associations in memory. The IAT is comprised of two tasks. In Task 1, participants are asked to respond rapidly with a specific key press to items representing two concepts (e.g., smoking + positive), and with a different key press to items from another two concepts (e.g., not smoking + negative). In Task 2, the assignments for one of the concept pairs is switched (such that not smoking + positive share a response, likewise smoking + negative). The key idea behind the IAT is that it is easier to map two concepts onto a single response when those concepts are more strongly associated in memory than when the concepts are unrelated or dissimilar (de Houwer, 2002). The critical measure (the IAT effect) is the difference in response times on Task 1 compared to Task 2.

The IAT effect is an index of the relative strength of mental associations. In the example above, it indicates whether mental associations are stronger between smoking and positive, and not smoking and negative, than between not smoking and positive, and smoking and negative. In studies that use positive and negative as two concepts (as above), the IAT effect is assumed to capture an implicit attitude, which has been characterized as the automatic associations people have between an object and evaluation (good or bad) (Rudman, 2004). The IAT has been used to investigate associative memory in psychopathology (Gemar et al., 2001; Teachman et al., 2001; Teachman and Woody, 2003), including the addictions (e.g., Palfai and Ostafin, 2003; Wiers et al., 2002; Jajodia and Earleywine, 2003). There is substantial evidence for the reliability, convergent validity, and discriminant validity of the IAT (Cunningham et al., 2001).

The IAT has been used to examine implicit attitudes in smokers (reviewed in Waters and Sayette, 2005; see also de Houwer et al., 2006). Swanson et al. (2001) investigated IAT effects for smoking vs. not smoking pictures and positive vs. negative words. Somewhat surprisingly, smokers performed better when smoking was paired with negative rather than positive words. This suggests that they have a negative implicit attitude toward smoking. However, non-smokers exhibited an even more negative implicit attitude toward smoking. The effect size for the between-group (smoker vs. non-smoker) difference in the IAT effect was moderate to large ($d = .70$). Two other studies also reported that non-smokers exhibited a significantly more negative implicit attitude than smokers (Huijding et al., 2005, exp. 1; de Houwer et al., 2006, exp. 1), and in both cases the smokers tended to exhibit negative implicit attitudes. Robust between-group (smoker vs. non-smoker) differences have also been reported on two variants of the IAT, the single-target IAT (Huijding and de Jong, 2006), and the go/no-go association test (Bassett and Dabbs, 2005).

Less research, however, has examined whether implicit attitudes are associated with measures of smoking motivation and dependence within samples of smokers. In a sample of young adult smokers ($n = 31$), Huijding and de Jong (2006) reported significant associations between implicit attitudes (on the single-target IAT) and both self-reported craving and nicotine dependence. Sherman et al. (2003) investigated whether the IAT effect is associated with cigarettes smoked per day, and whether the IAT effect is moderated by abstinence from smoking. Smokers were instructed to abstain for four hours prior to the session and were randomly assigned to either smoke or not smoke prior to completing the IAT. A group of non-smokers also completed the IAT. Consistent with the studies cited above, smokers (n = 156) exhibited a less negative IAT effect than a group of non-smokers (n = 79). Heavy smokers (n = 63, 15+ cigs/day) exhibited a significantly more positive IAT effect than lighter smokers (n = 93, < 15 cigs/day). However, there was no significant effect of 4-hr abstinence.

The effects of abstinence warrant further investigation for a number of reasons. First, in the Sherman et al. (2003) study there was a non-significant tendency for the 4-hr deprived smokers to exhibit a more positive (less negative) IAT effect than the just-smoked participants. Second, the 4-hr manipulation may not have been sufficient to detect significant effects of abstinence. Third, abstinence has a potent effect on craving, and, as noted above, craving has been reported to be associated with implicit attitudes (Huijding and de Jong, 2006). Last, contextual or "state" manipulations have been shown to significantly moderate implicit attitudes in other domains (Fazio and Olson, 2003). For example, Rudman (2004) reported that reading a tragic story about the consequences of smoking significantly altered the IAT effect (the IAT effect became more negative) compared to a "control" smoking story condition.

Automatic affective responses have also been assessed from physiological responses (Fazio and Olson, 2003). One such measure is the acoustic startle eyeblink response (see Bradley et al., 1999, for review). Startle responses to stimuli are typically assessed by measuring the strength of the orbicularis oculi electromyogram (EMG) following an unexpected acoustic probe (80–115 dB). The strength of the eyeblink response to the acoustic probe is associated with the affective valence of the stimulus. For example, blinks are larger when subjects view unpleasant (vs. neutral) pictures (e.g., Cook et al., 1992; Vrana et al., 1988) and are smaller when participants view positive (vs. neutral) pictures (Cuthbert et al. 1996). The acoustic startle response has been also used to study the affective properties of smoking cues (e.g., Cinciripini et al., 2006; Elash et al., 1995; Geier et al., 2000; Orain-Pelissolo et al., 2004).

In common with implicit attitudes assessed with the IAT, startle-probe responses are thought to capture, at least in part, automatic evaluations of stimuli. Affective startle modulation reflects automatic priming of biphasic appetitive or aversive motivational systems that is independent of conscious evaluation or social communication (Lang et al., 1990; Lang et al., 1997). However, few studies have compared the two measures (IAT, startle-probe responses). Phelps et al. (2000) reported that white participants exhibited 1) A negative IAT effect to unfamiliar black faces (vs. white unfamiliar faces); and 2) Larger startles to pictures of unfamiliar black faces (vs. white unfamiliar faces). Moreover, both the IAT effect and the startle responses correlated with activation of the amygdala, a brain structure known to mediate rapid, unconscious, evaluative processing (Phelps et al., 2000). The apparent similarity between the IAT and startle-probe data provides preliminary evidence that the two measures may assess a common underlying process (automatic affective evaluations).

In this study, we extended upon previous research in the following ways. First, we examined whether the IAT effect was moderated by a stronger abstinence manipulation than that previously used. Second, we examined whether the IAT effect was associated with a wider range of external variables relevant to smoking motivation and dependence. Third, we examined whether the IAT effect was associated with startle probe responses. Last, we recruited an older sample of smokers than has been typically used. Our overall goal was to evaluate the extent to which the IAT effect captures important information relevant to smoking motivation and dependence within a sample of older adult smokers.

2. Method

2.1 Participants

Participants were 57 smokers recruited from the Houston metropolitan area via newspaper and radio advertisements. To be included in the study, participants had to be 18 - 59 years old; report smoking at least 10 cigarettes per day; speak English; and have a functioning telephone. Participants were excluded if they reported that they were currently taking psychotropic medication, or if there was evidence of current psychiatric disorder, as assessed with the PRIME-MD. Participants were also excluded if they reported being color-blind. Females who were pregnant or nursing were also excluded. Participants were not seeking treatment for smoking cessation.

The study reported here was part of a larger study that examined the effects of nicotine and nicotine deprivation on affective and motivational processes. The results of the parent study will be reported elsewhere. The study was approved by the Institutional Review Board of the UT M. D. Anderson Cancer Center.

In total, 225 participants completed the telephone screening, of whom 62 were disqualified due to inclusion/exclusion criteria. Out of the 163 eligible participants, 92 attended a subsequent orientation session. Of these, 68 completed the 4 experimental sessions, and of these 58 completed the IAT at all four experimental sessions[1]. The final sample (55.9% black, 36.8% white) was comprised of 26 men and 31 women, and had an average age of 43.6 (SD = 9.87). On average, participants smoked 20.2 cigarettes/day (SD= 6.64), scored 5.46 on the Fagerstrom Test for Nicotine Dependence (FTND; Heatherton et al., 1991) (SD = 1.69), and had smoked for 21.9 years (SD = 9.75).

2.2 Procedure

A 10–15 minute preliminary telephone screening was conducted during which participants were given an initial description of the study design. Data were collected on age, smoking history, other tobacco use, major medical history, medication use, and pregnancy/lactation status. Participants also completed a version of the PRIME-MD, which was modified for use over the telephone (Spitzer, et. al., 1994). The PRIME-MD screens for the five major mental disorders (DSM-IV) most commonly encountered in the general population (mood, anxiety, somatoform, alcohol, eating disorders). When compared with a subsequent SCID (Structured Clinical Interview for DSM-III-R; Spitzer et al, 1989), the phone-based PRIME-MD has been found to successfully eliminate virtually all smokers with current psychiatric disorders (Cinciripini et al., 2004).

Eligible participants were invited to attend a 90-minute orientation visit, conducted at UT M. D. Anderson Cancer Center. At this orientation visit, to assess for past history of depression we administered a brief interview consisting of items based on the DSM-IV criteria for history of major depression (Cinciripini et al., 2006). Participants also completed a number of questionnaires assessing tobacco dependence, including the FTND.

Each participant completed 4 experimental sessions, scheduled at least three days apart. Each session began at the same time of day for each participant. They were instructed to abstain from smoking for 12-hrs before two of the sessions (AB), and to smoke normally before the other two sessions (NON). At one of the AB/NON sessions they smoked a cigarette about 40 min before completing the IAT (S), and at the other they did not smoke

[1]The IAT was introduced mid-stream into the study (after the first 10 participants). One participant's data from the IAT was procedurally excluded from all 4 sessions (by Greenwald et al.'s 2003 scoring algorithm, Table 4), leaving a final sample size of 57.

before completing the IAT (NS). Order of completion of the 4 conditions (AB-NS, AB-S, NON-NS, NON-S) was counterbalanced across participants. The mean session number (1–4) for each condition was 2.51, 2.60, 2.47, and 2.38 for the AB-NS, AB-S, NON-NS, NON-S conditions respectively. Participants were asked to limit their intake of coffee (or equivalent) to no more than 2 cups prior to 8:00 am on the day of the laboratory sessions.

The procedure for each laboratory session was as follows. Expired breath carbon monoxide (CO) levels were taken at the beginning of each session. At the AB sessions, participants were considered non-abstinent if they reported having smoked on that day or had high CO levels (> 10 ppm). Under these conditions, the abstinent session was re-scheduled. Participants completed: 1) A startle probe assessment, as described below; 2) A second startle probe assessment (participants either smoked a cigarette (S) or rested (NS) between the two startle assessments); 3) The Brief Questionnaire of Smoking Urges (QSU-brief; Cox et al., 2001) and the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988); 4) The computerized smoking Stroop task (Waters et al., 2003) and the Subjective Stroop Questionnaire (SSQ) (data will be reported in detail elsewhere2); 5) The QSU-brief, PANAS again; 6) The IAT; 7) Five items assessing outcome expectations from smoking (described below). All questionnaires were administered by computer.

2.3 Measures

2.3.1 Startle Probe Assessments—Electrodes (Ag-AgCl) filled with saline gel were attached in each participant’s right orbicularis oculi region (Fridlund and Cacioppo, 1986) to record startle eyeblink EMG. This signal was acquired and amplified with BIOPAC Systems’ (Goleta, CA) EMG100A module connected to BIOPAC Systems’ MP100WSW bioamplifier with a time constant of 1000-ms. Data were recorded and displayed using BIOPAC Systems’ AcqKnowledge III data acquisition software. After the sensors were attached, participants rested quietly for 5 minutes to become habituated to the environment. Startle response was manually scored offline in peak microvolts (μV) using the data acquisition software. Trials with clear movement artifact or excessive baseline activity were marked as missing. Due to these exclusions, there were no startle data from 21 assessments (9.5% of assessments); 5 participants did not provide any usable data at any session, and 1 participant did not provide any usable data at 1 session.

2.3.2 Affective Slide viewing—Forty-eight color pictures were presented (12 positive, 12 neutral, 12 negative, 12 cigarette). The positive, neutral, and negative pictures were selected from the International Affective Picture System (IAPS; Lang et al., 2005). The cigarette pictures, consisting of smoking cues such as images of burning cigarettes, have been used in previous studies (e.g., Cinciripini et al., 2006), and a validation check has been published (Carter et al., 2006). A PC using Psychology Software Tools’ E-prime software (Pittsburgh, PA) digitally projected a 91.5 cm × 122 cm image of the pictures, on a screen approximately 1.5 m from the participant.

Two separate blocks of trials (habituation and test), each consisting of 24 pictures, were presented using established procedures (e.g., Cinciripini et al. 2006, Cuthbert et al., 1996; Smith et al., 2005). Each block of 24 pictures included 6 pictures of each valence. Each picture was presented for 6 s and was then followed by a randomly determined inter-picture

[2]The participants were hooked up to the physiological monitoring system (BIOPAC) while completing the smoking Stroop task (the task administered by Waters et al. 2003), so that physiological responses (heart-rate, galvanic skin response, corrugator EMG activity, zygomaticus EMG activity) were assessed in real-time during task completion. (The participants were not hooked up while performing the IAT). Given that the Stroop reaction time data is linked to these physiological responses, we considered it appropriate to report the complete Stroop datasets (reaction time, physiological data) in a separate report. In addition, the smoking Stroop task is thought to assess a different construct (attentional responses) to the IAT.

interval that varied from 10 to 20 s. A different sequence of pictures was presented at each session. The order of pictures presentation in each pictures sequence was counterbalanced so that participants saw each picture equally often in the first through sixth positions within each block and so that each block occurred in the first or second position with equal frequency.

At the end of final laboratory session, the pictures were presented in a free-viewing procedure. The participants were asked to rate each picture by selecting a box on a 9-point scale on the following three dimensions: Happy vs. Unhappy (*Completely Happy* to *Completely Unhappy*); Excited vs. Calm (*Completely Aroused* to *Completely Calm*); and Craving for a Cigarette (*Extreme Craving* to *No Craving*).

2.3.4 Startle probe presentation—The acoustic startle stimulus consisted of a 50-ms 100 dB(A) presentation of white noise with instantaneous rise time. The startle stimuli were generated and amplified by E-prime software. The noise burst was presented binaurally with Sennheiser (Wedemark, Germany) HD500 headphones. A startle probe was presented during 16 of the 24 pictures in each block, at a random time of 2.5 to 5 s after picture onset. Counterbalancing for picture sequence was arranged so that, across subjects, each picture would be associated with a startle probe equally often. Each session began with four test startle probe trials before the first picture of each session. In addition, to enhance the unpredictability of the startle presentation, eight startle probes were presented during inter-picture intervals in each block. The complete startle probe assessment (including smoking or rest between blocks) took approximately 45 minutes.

Scoring: We computed a summary startle-probe score by taking a difference score between mean startle magnitude during neutral pictures and mean startle magnitude during smoking pictures, after participants had smoked/rested (second block); more positive startle-probe scores reflect greater startle attenuation by smoking pictures. (In the current paper, we do not report startle data from the positive and negative pictures). The mean startle-probe score (averaged across the four conditions, AB-NS, AB-S, NON-NS, NON-S) was significantly different from zero ($n = 52$, $M = 12.1$ μV, $SD = 19.8$, $p < .0001$), indicating that the smoking pictures did significantly attenuate startle (vs. neutral pictures). Using a split half approach and applying the Spearman-Brown formula (Parrott, 1991), the estimated internal reliability of startle responses on smoking and neutral pictures was good (mean $r = .93$ across sessions for both smoking, neutral pictures). The internal reliability of startle-probe scores (difference scores) was low (mean $r = .25$ across sessions).

2.3.5 Cognitive Assessment

The *Implicit Association Test*: The IAT was programmed using E-Prime (Schneider et al., 2002) and consisted of seven blocks: 1) Practice of categorization for the target concept (smoking/not smoking); 2) Practice of categorization for the attribute (good/bad); 3) First block of combined categorization task (Task 1) (smoking + good/not smoking + bad); 4) Second block for Task 1; 5) Practice of categorization for the target concept but with the response keys reversed from the 1) assignment (not smoking/smoking); 6) First block of alternative combined categorization task (Task 2) (e.g., not smoking + good/smoking + bad); 7) Second block for Task 2. The order in which participants perform the combined categorization blocks (i.e., 3–4, and 6–7) was counterbalanced across participants. Blocks 1, 2, and 3 each had 24 trials, and blocks 4, 5, 6, and 7 each had 48 trials. The IAT task took roughly 8 minutes to complete.

Stimulus materials: We used the same 12 cigarette and 12 neutral pictures as were used in the startle probe assessment for the smoking and not smoking categories respectively. We

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used 12 words to capture the good concept (Nice, Pleasant, Cool, Relaxing, Soothing, Restful, Smooth, Peaceful, Positive, Friendly, Satisfying, Calm) and 12 words to capture the bad concept (Nasty, Unpleasant, Dirty, Foul, Smelly, Unhealthy, Ugly, Negative, Antisocial, Depressing, Harmful, Revolting).

Procedure: On each trial, a stimulus (word or picture) was presented in the center of a computer monitor. On the top of the screen were labels (on each side of the screen) to remind participants of the categories assigned to each key for the current task. Participants responded to the categorization task by pressing either an "L" key or the "R" key on the response device. They were instructed to respond as quickly and as accurately as possible. In blocks 1, 2 and 5, the program randomly selected items from the stimulus lists. In blocks 3, 4, 6 and 7, the program randomly selected items under the constraint that the sequence of trials alternated between the presentation of a (smoking/not smoking) picture and the presentation of a (good/bad) word. If the participant responded correctly the program proceeded to the next trial, after an inter-trial interval of 150 ms. If the participant made an error, a red "X" appeared below the stimulus and remained there until the participant responded correctly. Participants were instructed to correct their errors as quickly as possible.

Scoring: We used the scoring algorithm recommended by Greenwald and colleagues to derive the IAT effect (Greenwald et al., 2003, Table 4). This scoring algorithm involves computing the difference score between mean response times per trial on Task 1 and Task 2, and dividing the difference score by the pooled standard deviation of response times. The resulting IAT effect, D, is similar to an effect-size measure. This scoring counteracts a "cognitive skill" artifact that had been observed with earlier scoring algorithms (Greenwald et al., 2003); the new IAT effect, D, is generally not correlated with overall mean RT (an index of general processing ability)[3]. The algorithm also eliminates 1) assessments on which a participant had response times of less than 300 ms on more than 10% of the trials (9 assessments from 4 participants, 3.9% of our assessments), and 2) all response times > 10,000 ms. Reaction times on incorrect responses were replaced by the block mean (correct responses) + 600ms.

We estimated the internal reliability of the IAT effect (D) by computing the IAT effects derived from blocks 3 + 6 and blocks 4 + 7, correlating these measures, and applying the Spearman-Brown formula to derive the split-half reliability coefficient (Parrott, 1991). The estimated internal reliability was good in all four sessions (mean r = .91).

2.3.6 Questionnaire Measures—*The QSU-Brief* assesses desire and intention to smoke. The 10-item measure assesses desire for the positive effects of smoking (Factor 1 Craving), and desire for relief of negative affect and an urgent need to smoke (Factor 2 Craving). We report data from the QSU assessment most proximal to completion of the IAT.

The PANAS assesses Positive Affect (PA; 10 items, e.g., enthusiastic, strong) and Negative Affect (NA; 10 items, e.g., distressed, upset). These scales have been shown to represent orthogonal dimensions of affect (Watson et al., 1988). We report data from the PANAS assessment most proximal to completion of the IAT.

***Smoking Outcome Expectancies* (OE):** Five items, based on items from a validated questionnaire (Copeland et al., 1995), assessed positive outcomes from smoking: "Smoking

[3]The correlations between the IAT effect D and mean reaction times were −.19, −.21, .04, −.15 (all ps > .1) for the AB-NS, AB-S, NON-NS, NON-S conditions respectively. In addition, Session (session 1–4, coded as a continuous variable) did not significantly predict the IAT effect D (Parameter Estimate = 0.048 (SE = 0.026) p = .06).

now will help me relax"; "Smoking now will energize me"; "A cigarette will taste good now"; "Smoking now will satisfy my cravings"; "Smoking now will help reduce boredom". Participants responded on 11-point Likert-type scales, ranging from 1 = No!!, 11 = Yes!!. These items were strongly inter-correlated (alpha ranged from .88 to .92 across the four states); we took an average score (OE) to represent positive outcome expectancies from smoking. OE scores were significantly moderated by abstinence state ($p < .001$) (Table 1) and associated with FTND scores ($p < .005$). OE ratings were also strongly correlated with QSU ratings (rs range from .80 to .92 across the 4 abstinence states).

2.4 Data Reduction and Analyses

We used repeated measures ANOVA to examine the effects of pre-session Abstinence (2 levels: AB, NON) and within-session Smoking (2 levels: S, NS) on the IAT effect, other state variables (startle-probe scores; QSU, PANAS, OE), and Session Number. These analyses used data from subjects with complete data from all four abstinence sessions (n = 53). It should be noted that participants were overnight-abstinent at test at one of the sessions (AB-NS). Pairwise comparisons were used to assess whether the IAT effect and other state variables at the AB-NS condition differed from the other conditions.

To examine the effects of an external variable on the IAT effect, we modeled the effects of Session (sessions 1–4; coded as a continuous variable) and the external variable (tested individually) on the IAT effect (using all 222 IAT scores) using Generalized Estimating Equations (GEE; Zeger et al., 1988) models. These analyses allow for the fact that participants had up to 4 observations (one for each level of Abstinence), and take into account the correlation of data within subjects. We used a compound symmetry structure, and empirically-based robust estimates of standard errors and z-scores. To test whether the effect of an external variable persisted when controlling for abstinence state, we added pre-session Abstinence and within-session Smoking to the model (combined model).

We examined the effects of FTND scores coded as 1) a continuous variable; and 2) a class variable, FTND-g, with three levels: "low-dependence" (FTND = 4 or less); "moderate-dependence" (FTND = 5); "high-dependence" (FTND = 6 or greater) (Jarvik and Henningfield, 1993).

To examine whether the effects of an external variable was moderated by pre-session Abstinence and within-session Smoking, we tested the interaction term between the external variable and these variables. A significant interaction term would indicate that the association between the external variable and the IAT effect differed across states.

3. Results

3.1 Biochemical validation of abstinence and smoking

The mean CO at the outset of the experimental session was 6.36 ppm (SD = 2.31), 6.75 ppm (SD = 2.39), 26.2 ppm (SD = 11.3), and 26.3 ppm (SD = 11.8) in the AB-NS, AB-S, NON-NS, NON-S conditions respectively. The mean reported cigarettes smoked prior to the session was 0.00 (SD = 0.00), 0.05 (SD = 0.29), 5.24 (SD = 2.86), and 5.60 (SD = 2.92)[4].

3.2 IAT effect—Across all assessments (N = 222) the mean IAT effect was −0.49 (SD = 0.73). The IAT effect was significantly different from zero in all four conditions (by 1-

[4]Participants were required to refrain from smoking for 12-hours before the AB sessions, but the research assistants completed 2 assessments (AB-S condition) when participants reported smoking on the test day ("violators") if CO levels < 10 ppm. The primary analyses used data from all assessments (N = 222); key results held up if the violators were excluded.

sample t-test, all ps < .0001). Thus, in all conditions, participants performed better when smoking was paired with bad than when smoking was paired with good.

3.3 Effects of pre-session Abstinence and within-session Smoking

A repeated measures ANOVA revealed no effects of pre-session Abstinence or within-session Smoking on Session Number (1–4) (ps > .3), confirming that condition was not confounded with practice on the task. Table 1 shows the summary statistics of the IAT effect broken down by condition. A repeated measures ANOVA revealed main effects of pre-session Abstinence, F (1, 52) = 4.61, p < .05, and within-session Smoking, F (1, 52) = 4.48, p < .05, but no interaction (p > .2). Pairwise contrasts revealed that the IAT effect on the NON-S condition was significantly more negative (ps < .05) than the IAT effect at the other three conditions (AB-NS, AB-S, NON-NS), which did not differ from each other (ps > .1). Repeated measures ANOVA conducted on QSU, PANAS-NA, and OE scores revealed the expected main effects of pre-session Abstinence and within-session Smoking, with the highest ratings for all these measures occurring in the AB-NS condition (Table 1). Repeated measures ANOVA conducted on startle-probe scores did not yield a significant effect of pre-session Abstinence or within-session Smoking (ps > .1).

3.4 Associations with state variables

Using GEE analyses, Table 2 shows that the IAT effect was significantly associated with QSU ratings, PANAS-NA (but not PANAS-PA) ratings, and OE ratings. These associations persisted when controlling for pre-session Abstinence and within-session Smoking (Table 2). The IAT effect was not significantly associated with startle-probe scores (p > .1) (Table 2)[5]. Tests of interaction effects revealed that the associations between the state variables listed in Table 2 and the IAT effect were not significantly moderated by pre-session Abstinence and within-session Smoking (all ps > .1).

3.5 Associations with trait variables

Table 2 shows that cigarettes/day and years smoking were not significantly associated with the IAT effect[6]. However, FTND scores were significantly associated with the IAT effect (Table 2, Figure 1). The IAT effect became more positive (less negative) at higher levels of FTND scores. When FTND was coded as a class variable with three levels (low-, moderate-, high-dependence), the effect of FTND-g on the IAT effect was significant, Chi-Square = 7.09, df = 2, p < .05; the high-dependence participants had a significantly more positive IAT effect than the low-dependence participants, Parameter Estimate =-0.52 (SE = 0.18), p < .005 (the moderate-dependence participants did not differ significantly from the low- and high-dependence groups, ps > .1) (Fig. 1). The FTND by pre-session Abstinence and FTND by within-session Smoking interactions were not significant (p > .1), indicating that the association between the FTND and the IAT effect was not significantly moderated by pre-session Abstinence and within-session Smoking. Gender was not associated with the IAT effect (Parameter Estimate = 0.11 (SE = 0.18), p > .5, not shown in Table 2).

3.6 Associations with picture ratings

Using GEE analyses, Happy-Unhappy ratings on neutral or smoking pictures, Excited-Calm ratings on neutral or smoking pictures, and Craving for a cigarette ratings on neutral or

[5]The smoking Stroop effect was not significantly associated with the IAT effect (Parameter Estimate = 0.0004, SE = 0.0003, p > .19, not shown in Table 2). The relationship between the smoking Stroop effect and the IAT effect was not moderated by pre-session abstinence, or within-session smoking (ps > .2)

[6]Following Sherman et al. (2003), we also dichotomized cigarettes per day into light (<15 per day) and heavy smokers (15+ per day). When so coded, there was some evidence that heavy smokers (M = −0.43) had more positive (less negative) IAT effects than light smokers (M = −0.87) (Parameter Estimate = −0.43, SE = 0.25, p = .07) (not shown in Table 2).

smoking pictures, were not associated with the IAT effect (all ps > .1) (not shown in Table 2).

4. Discussion

The main findings of the study were that 1) Overall, the IAT effect assessed with the smoking IAT had good internal reliability and was generally negative; 2) The IAT effect was moderated by pre-session abstinence and acute Smoking; 3) The IAT effect was associated with a number of dependence-relevant external variables, including self-reported craving and tobacco dependence; 4) These associations persisted when controlling for abstinence state; and 5) The IAT effect was not associated with a physiological measure of automatic affective processing, startle responses on smoking (vs. neutral) pictures. We will discuss each finding in turn.

Averaged over all assessments, the IAT effect was negative (Mean IAT effect = −0.49, SD = 0.73). As noted earlier, this finding has been previously observed (though non-smokers generally exhibit an even more negative IAT effect) (Huijding et al., 2005; de Houwer et al., 2006; Sherman et al., 2003; Swanson et al., 2001). A negative IAT effect has generally been interpreted in the literature as reflecting a negative implicit attitude to smoking (preference for smoking over not smoking). Blanton and Jaccard (2006) have argued that the location of the IAT's zero point has not yet been firmly established, and so the meaning of absolute IAT scores is uncertain. On the other hand, Greenwald et al., (2006) provided evidence that the observed zero point corresponds to the true zero point in one context (preference for one presidential candidate over another). Accordingly, consistent with the literature (e.g., de Houwer et al., 2006; Swanson et al., 2001), we interpret the negative IAT effect as reflecting a negative implicit attitude, with the caveat that future research should 1) identify the zero point in the current context (smoking), and 2) link absolute IAT scores to meaningful real world events, such as outcomes in smoking cessation.

If the negative IAT effect is taken at face value, the relevance of implicit attitudes for explaining smoking behavior can be questioned, because it is not obvious how negative implicit attitudes might maintain smoking. However, it has been suggested that societal influences can impact responses on the IAT (Fazio and Olson, 2003), such that the IAT effect reflects not only the automatic mental associations of the participant but also societal views. Given the strong negative societal view of smoking, this might explain why even smokers can exhibit negative implicit attitudes (de Houwer et al., 2006). That is, negative societal influences may shift all participants' responses toward the negative end of the continuum. According to this view, smokers may have more positive implicit attitudes than that revealed by the IAT, but this is masked by the impact of societal influences[7].

Notwithstanding, even if smokers have a negative implicit attitude for the majority of the time, changes in motivational or emotional state may increase the probability of a positive implicit attitude. Implicit attitudes may be dynamic, fluctuating over time like self-reported craving and negative affect. Rapid changes in implicit attitudes may conceivably influence relapse risk in a similar manner as rapid changes in negative affect (Shiffman and Waters, 2004). The IAT effect in the current study was associated with subsequent positive outcome expectations from smoking a cigarette. Thus, an individual with a positive implicit attitude is at risk for expecting positive outcomes from smoking a cigarette, and these processes might serve to undermine attempts to maintain abstinence.

[7]Some evidence for this position is derived from a study that reported that smokers show positive implicit attitudes using a personalized version of the IAT that is purportedly less sensitive to socio-cultural influences that the standard IAT (de Houwer et al., 2006; Olson and Fazio, 2004).

Relatedly, the IAT effect was significantly moderated by pre-session Abstinence and within-session Smoking. Smoking a cigarette makes the IAT effect more negative, and this effect was consistent across pre-session abstinence states (no pre-session Abstinence by within-session Smoking interaction). In the AB-NS condition, participants were overnight-abstinent at test. Although the IAT effect was most positive in this condition, it was only significantly different from the IAT effect in the NON-S condition, where the IAT effect was most negative (Table 1). The NON-S condition is arguably the condition that most closely resembles the smokers' typical smoking behavior. Before this session, participants were instructed to smoke normally (and they reported smoking over 5 cigarettes before the session), and they also smoked a cigarette during the session. Thus, participants were presumably satiated at the time of test. This is reflected in the craving ratings: QSU ratings were lower in the NON-S condition than in all other conditions (Table 1). In the other three conditions, normal smoking behavior had been interrupted in some way, and the IAT effect became more positive (less negative).

The IAT effect was robustly and positively related to self-reported craving (Table 2). Moreover, these associations persisted when controlling for pre-session Abstinence and within-session Smoking (Table 2). The data suggest that for individuals in the same abstinence-state, craving continues to predict their implicit attitude. The IAT effect was also significantly associated with FTND scores (Fig. 1a), with more dependent individuals exhibiting more positive implicit attitudes. These data are noteworthy, because there are few reports of associations between implicit measures and tobacco dependence (Waters and Sayette, 2005). The association between implicit attitudes and FTND scores was not moderated by pre-session Abstinence or by within-session Smoking, suggesting that the association was consistent across different states.

The IAT effect was not significantly associated with the startle-probe measure (Table 2). Indeed, the IAT and startle-probe measures exhibited different patterns of data. Participants exhibited significantly negative implicit attitudes on the IAT, indicating that the smoking pictures were more closely automatically associated with negative than with positive words. On the startle-probe, however, the (same) smoking pictures significantly suppressed startle responses in comparison to neutral pictures and therefore acted in a similar fashion to positive pictures (Cuthbert et al., 1996). Put another way, on the IAT the smoking pictures appeared to receive an automatic negative evaluation (but see comments above on the IAT's zero point, Blanton and Jaccard, 2006), whereas on the startle-probe they appeared to receive an automatic positive evaluation. This might be explained if the societal influences noted above impact the IAT effect more than startle-probe responses. In any case, the data suggest that IAT and startle capture different components of affective processing.

The study had a number of strengths. First, to be best of our knowledge, this is the first study in the addictions to compare affective processes assessed with the IAT with affective processes assessed with startle responses. We used the same stimulus materials (neutral/smoking pictures) for both assessments, thereby reducing the likelihood that method differences underlie differences in performance. Second, we had a sufficiently large sample of assessments (N = 222) to detect associations between the IAT effect and external variables. Third, we included a number of dependence-relevant measures in our assessment battery, which enabled a comprehensive analysis of the associations with external variables. Last, our community sample of smokers was older than the student samples previously used, thereby confirming that the IAT can be profitably applied in older samples of smokers.

The study also had limitations. First, startle responses and the IAT were measured at different time-points in the procedure, and the order of presentation (of startle/IAT assessments) was not counterbalanced. Thus, we cannot rule out the possibility that the different results for the two measures reflect method differences. Second, the pictures in the startle-probe assessment were presented for 2.5 to 5 seconds before probe onset. Though typical, this procedure allows for the possibility that non-automatic processing may occur prior to probe onset. For example, although they receive no instruction, participants might attempt to consciously suppress the effects of picture content or engage in other processing that may modify the response. For example, Piper and Curtin (2006) have reported that consciously-mediated emotion regulation strategies impact startle responses. Individual differences in non-automatic processing may influence responses to the pictures, and reduce associations with IAT effects. As a further complication, the IAT may also be influenced by strategic processing (e.g., Rothermund and Wentura, 2004; Greenwald et al., 2005). Future research could use brief picture presentations that may reveal a more immediate affective response (Larson et al., 2005). Third, the estimated internal reliability of the startle-probe scores was low. Other studies have also reported low internal reliability for affective modulation of startle (Hawk and Cook, 2000). The lack of association between the IAT effect and startle-probe scores may reflect, in part, measurement error of the latter, and further work is required to examine this issue further. Last, we did not include a measure of explicit attitudes other than the picture rating measure, which was only administered at the end of the final laboratory session. Thus, the analyses examining associations between implicit and explicit attitudes may have had limited power to detect associations.

In sum, there is evidence that implicit attitudes assessed with the IAT are associated with smoking motivation and dependence. To the best of our knowledge, the current paper is the first to show that the IAT effect can be significantly moderated by abstinence-state, and the first to report associations with measures of smoking motivation and dependence in a group of older adult smokers. The study also provided evidence that the IAT does not capture the same type of automatic affective response as that captured by the startle-probe responses.

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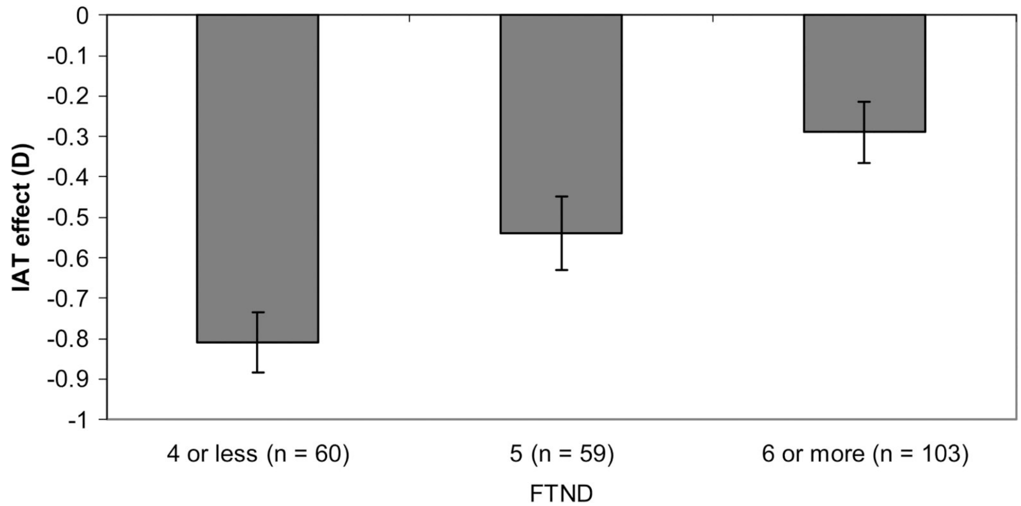

Figure 1.
Association between IAT effect and FTND scores.

Table 1

Summary statistics for the IAT effect, startle-probe scores, and QSU, PANAS, OE ratings.

	AB-NS	AB-S	NON-NS	NON-S	F Abstinence	F Smoking	F Abstinence × Smoking
Startle[1] (μV)	3.8 (42.4)	10.7 (25.0)	16.8 (27.6)	15.9 (32.6)	3.31	0.87	1.63
QSU (0–10)	6.71^{a} (2.82)	3.79^{b} (2.95)	4.53^{c} (3.24)	2.58^{d} (2.97)	58.6^{**}	75.4^{**}	3.76
PANAS-NA (1–5)	1.81^{a} (0.71)	1.57^{b} (0.52)	$1.67^{a,b}$ (0.66)	1.60^{b} (0.50)	0.78	9.69^{**}	3.58
PANAS-PA (1–5)	3.11 (0.79)	2.97 (0.76)	2.94 (0.83)	3.10 (0.84)	0.04	0.06	4.64^{*}
IAT (D score)	-0.41^{a} (0.72)	-0.48^{a} (0.68)	-0.46^{a} (0.73)	-0.64^{b} (0.78)	4.61^{*}	4.48^{*}	1.41
OE (1–11)	7.13^{a} (2.88)	5.70^{b} (3.03)	5.87^{b} (2.96)	4.83^{c} (2.73)	16.3^{**}	18.8^{**}	0.68

Note: Mean (SD) of state measures. Data are shown for assessments with IAT data (ns = 55, 57, 55, 55 for the AB-NS, AB-S, NON-NS, NON-S conditions respectively). F values reflect main effect of pre-session Abstinence and within-session Smoking, and their interaction, in repeated measures ANOVA.

[1] Startle-probe score (see text for details): ns = 49, 52, 50, 50 for the AB-NS, AB-S, NON-NS, NON-S conditions respectively.

* Key: $p < .05$;

** $p < .01$. Values indicated by different letters were significantly different ($p < .05$) in pairwise comparisons; values sharing the same letter were not significantly different. QSU = Questionnaire for Smoking Urges; PANAS = Positive and Negative Affect Scale; OE = Outcome Expectancies. See text for further details.

Table 2

Associations between the IAT effect and external variables.

External Variable	Parameter Estimate External Variable (SE)	
Cigarettes/Day	−0.015	(0.015)
+ Abstinence, Smoking	−0.015	(0.015)
Years Smoking	−0.0122	(0.0081)
+ Abstinence, Smoking	−0.0121	(0.0080)
FTND[1]	0.099*	(0.046)
+ Abstinence, Smoking	0.100*	(0.045)
Startle-Probe score	−0.0002	(0.0008)
+ Abstinence, Smoking	0.0004	(0.0007)
QSU total	0.038**	(0.011)
+ Abstinence, Smoking	0.028*	(0.013)
PANAS-NA	0.13**	(0.042)
+ Abstinence, Smoking	0.085	(0.044)
PANAS-PA	−0.042	(0.058)
+ Abstinence, Smoking	−0.040	(0.057)
OE	0.043**	(0.012)
+ Abstinence, Smoking	0.030*	(0.014)

Note. Associations between external variables and the IAT effect (D score), using GEE analyses. Data shown (left side of table, upper row) are parameter estimates (SE) of external variables from models containing Session (coded as a continuous variable, not shown in table) and the external variable (tested individually). The lower row shows parameter estimates (SE) of external variables from models including pre-session Abstinence and within-session Smoking (parameter estimates of Abstinence, Smoking not shown).

*Key: $p < .05$;

**$p < .01$. [1]FTND scores were coded as a continuous variable; QSU = Questionnaire for Smoking Urges; PANAS = Positive and Negative Affect Scale; OE = Outcome Expectancies. See text for further details.