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Approach bias modification in inpatient psychiatric smokers

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ABSTRACT

Drug-related automatic approach tendencies contribute to the development and maintenance of addictive behavior. The present study investigated whether a nicotine-related approach bias can be modified in smokers undergoing inpatient psychiatric treatment by using a novel training variant of the nicotine Approach-Avoidance-Task (AAT). Additionally, we assessed whether the AAT-training would affect smoking behavior. Inpatient smokers were randomly assigned to either an AAT-training or a sham-training condition. In the AAT-training condition, smokers were indirectly instructed to make avoidance movements in response to nicotine-related pictures and to make approach movements in response to tooth-cleaning pictures. In the sham-training condition, no contingency between picture content und arm movements existed. Trainings were administered in four sessions, accompanied by a brief smoking-cessation intervention. Smoking-related self-report measures and automatic approach biases toward smoking cues were measured before and after training. Three months after training, daily nicotine consumption was obtained. A total of 205 participants were recruited, and data from 139 participants were considered in the final analysis. Prior to the trainings, smokers in both conditions exhibited a stronger approach bias for nicotine-related pictures than for tooth-cleaning pictures. After both trainings, this difference was no longer evident. Although reduced smoking behavior at posttest was observed after both trainings, only the AAT-training led to a larger reduction of nicotine consumption at a three-month follow-up. Our preliminary data partially support the conclusion that the AAT might be a feasible tool to reduce smoking in the long-term in psychiatric patients, albeit its effect on other smoking-related measures remains to be explored.

1. Introduction

Although the prevalence of tobacco smoking declined over the last few decades, tobacco smoking still constitutes one of the most common addictive behaviors. In addition, according to the National Health Interview Survey, 70% of current smokers desire to quit smoking, but only less than 5% succeed to refrain from smoking for at least three months (Centers for Disease Control and Prevention, 2002). Also, the attendance of smoking cessation programs is rather low (Hughes, 2003). This indicates a high need to develop low-threshold, easy-to-access research-based interventions. In addition, there is strong evidence for a high association of tobacco smoking and mental illness, with the prevalence of smoking being two to three times higher in the mentally ill than in the general population (Leonard et al., 2001). In addition, psychiatric smokers consume more than one third of all cigarettes smoked (Dani and Harris, 2005), signaling that smoking intensity is dramatically high in this particular group. As a result, psychiatric smokers experience a higher incidence of tobacco-related diseases such as cardiovascular diseases, lung diseases, and cancer (Colton and Manderscheid, 2006) and mortality (Lawrence et al., 2003). Smoking can also alter the efficacy of medications which might lead to exaggerated and more frequent psychiatric symptoms, an increased number of hospital admissions and the prescription of higher medication doses (Williams and Ziedonis, 2004; Dalack and Glassman, 1992). Despite this, psychiatric smokers are characterized by a reduced motivation to quit, and tobacco smoking among these patients remains ignored or even encouraged by professional

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health care providers (Prochaska et al., 2014). Although the American Psychiatric Association (2006) identifies psychiatric hospitalizations as promising settings to treat nicotine dependence, tobacco treatment in psychiatry settings constitutes an underserved field. Therefore, clinically sound, hospital-based tobacco cessation trials are needed in order to inform clinical practice.

According to dual-process models of addiction, addictive behavior arises from an imbalance between a reflective, regulatory system and an automatic, approach-oriented system (Deutsch and Strack, 2006; Wiers et al., 2013a). Specifically, the reflective system relies on symbolic processing, is goal-directed, limited in capacity and incorporates fast and flexible learning, whereas the automatic system relies on memory associations, is goal-independent, hard to control, relatively unconsciously and hard to change (Wiers et al., 2013a; Stacy and Wiers, 2010). In particular, cigarette smoking and frequent exposure to nicotine-related cues leads to a sensitized automatic approach-oriented system at the expense of the regulatory system (Wiers et al., 2013a). As a result, strengthened automatic processes underlying nicotine dependence can lead to various cognitive biases including attention, memory, and automatic approach biases (Bardin et al., 2014; Bradley et al., 2008; Mogg et al., 2005). Recent research has repeatedly linked the automatic approach bias to nicotine dependence and tobacco craving (Machulska et al., 2015; Wiers et al., 2013b). In this context, the Approach-Avoidance-Task (AAT) – initially designed to assess automatic avoidance tendencies in anxious individuals (Rinck and Becker, 2007) – has proved to be a useful and valid task for re-training automatic approach tendencies in the field of alcohol use (Wiers et al., 2009; for re-training see Eberl et al., 2013; Wiers et al., 2011), cannabis and heroine dependence (Cousijn et al., 2011; Zhou et al., 2012), and recently nicotine dependence (Machulska et al., 2015; Wiers et al., 2013b). During AAT, participants view a series of pictures on a computer screen and receive instructions to ignore image content and to react to a content-irrelevant feature such as picture orientation, by either pulling or pushing a joystick attached to the computer. Pulling the joystick increases picture size, while pushing the joystick decreases it. This "*zooming feature*" creates a sense of approaching vs. avoiding the picture by combining arm movements with visual feedback. Also, this feature disambiguates the task because without visual feedback it remains unclear whether participants interpret arm movements with reference to their own body (as intended by the AAT) or with reference to the object depicted on the computer screen (Rinck and Becker, 2007). The rationale behind this task is that reaction times vary as a function of picture content. Most recently, it was shown that current smokers are faster at pulling nicotine-related pictures than at pushing them, indicating an automatic approach bias for nicotine stimuli (Machulska et al., 2015). Hence, similar to other cognitive biases, an approach bias toward nicotine might be a maintaining factor in nicotine dependence, as ex-smokers and non-smokers do not show this pattern of behavior (Wiers et al., 2013b).

Cognitive biases during the course of addiction can be changed systematically as shown in Cognitive Bias Modification (CBM) programs. For instance, studies using a modified AAT where picture content and arm movements were confounded (i.e., presentation of all drug-related pictures in push-format and all alternative pictures in pull-format) have yielded encouraging results in the treatment of alcohol dependent patients. After four sessions of alcohol-avoidance training, abstinent patients' initial approach bias for alcohol changed into an avoidance bias, and relapse rates at one-year follow-up were approximately 10% lower than in various control conditions (Eberl et al., 2013; Wiers et al., 2011). In addition, change in alcohol-approach bias mediated this clinical effect. These results point to the fact that the re-training AAT could be a promising and feasible novel tool to change dysfunctional approach biases toward drug stimuli, and thereby enhance treatment outcome. Furthermore, the AAT training bears the advantage not only to train addicted individuals to avoid drug-associated stimuli (e.g., alcohol), but provides an alternative stimulus category to be approached (e.g., non-alcoholic drinks). However, studies using the alcohol re-training AAT so far only addressed the prevention of relapse in abstinent alcoholics who were highly motivated to remain abstinent. Effects of the training on the reduction of other addictive drugs (e.g., nicotine) and other variables associated with drug use (i.e. craving, attitude toward drug use etc.) and the impact of different motivational states of abstinence are rather scarce. For instance, only a single study demonstrates the usefulness of single-session nicotine-avoidance training in changing implicit attitudes toward smoking (Macy et al., 2015). Another pilot study implemented a web-based nicotine-approach bias re-training and reported reduced smoking behavior (Wittekind et al., 2015). However, interpretation of these results is constrained by the fact that smoking reduction was not directly assessed (Macy et al., 2015), that no active control group was applied or that information on training frequency was entirely missing (Wittekind et al., 2015). Moreover, to our knowledge, no study so far tested the effect of multi-session training on long-term smoking behavior or tested whether smoking cessation therapy efficacy can be increased by the additional application of an AAT training, as suggested previously (Attwood et al., 2008; Field et al., 2009; Wiers et al., 2011). In the present study, we aimed to address these shortcomings and therefore examined the effect of multiple sessions of nicotine-avoidance AAT-training as an add-on to a short cognitive behavior therapy-oriented smoking intervention on long term smoking reduction.

We hypothesized that providing smokers under inpatient psychiatric treatment with a training variant of the nicotine-AAT as compared to sham-control training would diminish an initial nicotine-related approach bias and reduce daily nicotine consumption. Furthermore, we assumed that change in nicotine approach bias would mediate this treatment outcome. Finally, we expected both training variants would lead to improvements in associated measures such as explicit smoking-related cognitions, degree of nicotine dependence and/or motivation to quit smoking.

2. Methods

2.1. Participants

We recruited 205 adult smokers who had been admitted to inpatient psychiatric therapy. The study was conducted in detoxification, rehabilitation and depression units of the LWL-Clinic in Dortmund, Germany. Smokers were included if they had smoked cigarettes within the last 30 days and had smoked more than 100 cigarettes in their entire lifetime. Our final sample consisted of both smokers who were motivated to quit but also participants without any predefined abstinence goal. Exclusion criteria were an indication of schizophrenia spectrum or other psychotic disorders (4), neurological syndromes, such as Korsakoff's syndrome (7), insufficient German language skills (5) and withdrawal at (5) or immediately after the first session (36). One patient indicated to having already stopped smoking a month earlier, and two patients stated smoking a pipe or an e-cigarette exclusively and were therefore subsequently excluded from further analyses. Hence, our final sample compromised 145 patients. Participation was entirely voluntary, and patients were not paid for participation. All patients received a booklet including information on nicotine dependence.

The study was approved by the local Ethics Committee of the Ruhr-Universität Bochum and was conducted in accordance with the Declaration of Helsinki. Participants provided a written informed consent to the intervention prior to their inclusion in our study.

2.2. Clinical assessment and self-report measures

A trained clinical psychologist diagnosed patients using the Mini-DIPS (Margraf, 1994). Data from 37 participants could not be obtained due to study withdrawal or refusal to take part in the diagnostic interview. Detailed information on patients' psychiatric diagnoses and reasons for hospitalization are provided within Supplemental Material (see SA).

To measure the *degree of nicotine dependence*, the Fagerström Test for Nicotine Dependence was used (FTND; Heatherton et al., 1991; German version: Bleich et al., 2002). The FTND is a widely used self-report measure, consisting of six items aimed to capture the degree of nicotine dependence on a range from 0 to 10. According to Heatherton and colleagues (1991), scores between 0 and 2 indicate no or very weak dependence, scores between 3 and 4 weak dependence, a score of 5 moderate dependence, scores between 6 and 7 strong dependence, and scores between 8 and 10 very strong nicotine dependence.

In order to access participants' *readiness to quit smoking*, we used the Stages of Change Scale (Prochaska et al., 1991; German version: Jäkle et al., 1999). The scale assigns smokers to different time intervals of change: (a) pre-contemplation, (b) contemplation, (c) preparation, (d) action, (e) maintenance. Items (d) and (e) served as manipulation checks for smoking status.

Motivation/commitment to abstinence was assessed by the Thoughts About Abstinence Scale (Hall et al., 1990). Smokers were required to select one of six abstinence goals: (a) total abstinence, never use again, (b) total abstinence, but realize a slip is possible, (c) occasional use when urges strongly felt, (d) temporary abstinence, (e) controlled use, and (f) no goal. Subsequently, patients also rated on 10-point Likert-scales (a) their desire to quit, (b) the expected success in quitting, and (c) the expected difficulty of quitting.

Attitude toward smoking was assessed by a set of eight positive and negative adjectives: good-bad, healthy-unhealthy, sexy-unsexy, pleasant-unpleasant, harmless-harmful, sociable-unsociable, ugly-glamorous and calming-stressful (Swanson et al., 2001). Scales ranged from −3 to +3, with a score of −3 meaning an extremely negative and +3 meaning an extremely positive attitude toward smoking.

Patients were required to indicate their level of cigarette *craving* on a 6-point Likert-scale ranging from 0 (“not at all”) to 5 (“very high”).

2.3. Experimental design

2.3.1. Assessment-AAT (Approach-Avoidance-Task)

Patients completed pre- and posttest assessment-AATs to identify an initial approach bias toward nicotine-related stimuli and to measure whether this bias diminished after trainings. During the assessment task, nicotine-related or tooth-cleaning pictures as control images were presented on a computer screen. Stimuli from both picture categories were derived from Stippekohl et al. (2010) and were comparable in terms of dimension, shape and color. Noteworthy, both nicotine-related and tooth-cleaning pictures incorporate highly similar arm movements (i.e., moving a small object towards the mouth). Thus, we chose tooth-cleaning images to control for the type of movement involved in cigarette smoking. Also, smokers rated tooth-cleaning pictures as neutral with respect to valence and arousal (Stippekohl et al., 2010). Furthermore, we recently showed that tooth-cleaning pictures were neither approached nor avoided by smokers in the AAT (Machulska et al., 2015). Each of the categories contained 15 images presented in a quasi-random order (at most three equal rotations and picture categories in a row). The images were rotated either 3° to the left or 3° to the right. A joystick was connected to the computer, and patients were instructed to ignore image content and to pull pictures rotated to the left and to push pictures rotated to the right, as quickly and accurately as possible. Upon a pull movement, picture size increased, whereas upon a push movement, picture size decreased, creating an impression of approaching vs. avoiding the depicted stimulus. Participants had to execute the correct movement fully to make the picture disappear. Nicotine and tooth-cleaning pictures had to be pulled and pushed equally often. Required responses were practiced with pictures unrelated to smoking or tooth-cleaning pictures. Each assessment-AAT contained 250 trials in total. Patients were allowed to take a short break halfway through. AAT-sessions took approximately 15 min.

2.3.2. Trainings and experimental manipulation

Patients were randomly assigned to one of the two conditions (AAT-training vs. sham-training). The AAT-training was similar to the assessment-AAT, with the exception that all nicotine-related images were presented in push-away format and all tooth-cleaning images were presented in pull-closer format. Thus, patients assigned to the AAT-training condition were consistently trained to avoid nicotine and to approach tooth-cleaning pictures. Those assigned to the sham-training condition received an AAT equal to the assessment-AATs and were not trained to avoid nicotine (or to approach tooth-cleaning pictures). In both conditions, as in the assessment-AATs, patients received the instruction to ignore picture content and to pull pictures rotated to the left and to push pictures rotated to the right. Patients were trained in four sessions.

In addition to the trainings, all patients took part in a regular smoking-cessation intervention based on psychoeducation and motivational interviewing. Smoking intervention sessions took about 1 h each time and were given three times.

2.4. Procedure

Smokers completed five sessions in total. At Session 1, demographics and pretest measures (assessment-AAT and self-report measures) were administered. Afterward, smokers were randomly assigned either to the experimental or to the sham-control condition. The first training (AAT-training or sham-training) started at the end of session one. Thereafter, training sessions were performed on consecutive days and were accompanied by a regular smoking cessation program. At Session 5, patients performed the posttest, which was identical to the pre-test in Session 1. Three months after participation, all participants were contacted by phone or e-mail and had to indicate the number of cigarettes smoked daily.

2.5. Data preparation and statistical approach

To fill in missing data, we used modified Intention-To-Treat (ITT) principles (Fergusson et al., 2002) and the Last-Observation-Carried-Forward (LOCF) method.

Error trials were excluded from further analyses. Reaction times (RTs) were measured from the onset of picture presentation to disappearance of the picture upon a full correct movement. Since median scores are less influenced by outliers than mean scores, we calculated AAT-bias scores by subtracting median RTs for pulling a picture from median RTs for pushing a picture (see Rinck and Becker, 2007). Thus, positive AAT-scores are indicative of an approach bias, whereas negative AAT-scores are indicative of an avoidance bias for the particular image category. Data from six patients were excluded due to excessive errors (≥40%). Hence, our final sample comprised 73 smokers in the AAT-training condition and 66 smokers in the sham-training condition.

To test the change in AAT bias scores, we conducted a 2 × 2 × 2 mixed ANCOVA with training condition (AAT-training vs. sham-training) as between-subjects factor and picture content (nicotine-versus tooth-cleaning pictures) and time (pre versus post) as within-subjects factors. Literature on approach-bias modification suggests that subjective drug craving is associated with responsiveness to training (Wiers et al., 2010). Given that patients smoked ad libitum prior to the sessions, in order to control for a possible confounding effect of craving, craving scores were entered as covariates into the analysis.

To evaluate the effect of training on nicotine consumption, we conducted a 2 × 3 mixed ANCOVA with condition as between-subjects factor, time (pretest, posttest, follow-up) as within-subjects factor, and craving scores as covariates. Daily nicotine consumption constituted the dependent variable.

To test the effect of training on other smoking-related variables (i.e., craving, FTND, smoking attitude, readiness to quit, motivation/commitment to abstinence, subjective evaluation of the picture set), we carried out a 2(condition) × 2(time: pre versus post) repeated measures MANOVA. Significant multivariate effects were clarified with separate ANOVAS on each dependent variable. In addition, in case of significant interactions, discriminant factor analyses were conducted to identify possible associations between each of the dependent variables and group assignment.

Finally, we investigated whether change in AAT-bias would mediate the effect of training condition on nicotine consumption. To test the indirect effect, we used bias corrected confidence intervals derived from bootstrapping (1000 samples), since this method does not require distributional assumptions about the variables and minimizes the likelihood of Type I error (Preacher and Hayes, 2008).

Unless otherwise stated, test assumptions can be considered as met (see the supplementary materials section for a detailed discussion of test assumptions). Significant interactions were followed back by means of simple effect analyses. The level of significance was considered $p < .05$ (two-tailed). All analyses were performed using IBM SPSS Statistics for Windows 20 and the macro PROCESS written and provided by Andrew Hayes (2013).

3. Results

3.1. Sample characteristics before training

As shown in Table 1, groups were comparable on age, gender ratio, psychiatric variables and variables regarding smoking history (*ps* > .05). At pretest, groups did not differ in smoking-related variables such as craving, nicotine dependence, smoking attitude and motivation to quit smoking (*ps* > .05, see Table 2).

3.2. AAT approach tendencies and training effects

At pretest, groups did not differ in AAT-bias scores for nicotine-related pictures (AAT-training: adjusted *AAT-bias* = 12, *SE* = 12; sham-training: adjusted *AAT-bias* = 27, *SE* = 12), $F < 1$; $p > .364$, or tooth-cleaning pictures (AAT-training: adjusted *AAT-bias* = −16, *SE* = 12; sham-training: adjusted *AAT-bias* = −13, *SE* = 12), $F < 1$; $p > .888$. There was a significant main effect of picture category, $F(1,268) = 5.56$; $p = .019$; $\eta^2 = .02$, qualified by a significant time × picture category interaction, $F(1,268) = 5.43$; $p = .021$; $\eta^2 = .02$. Simple effects on the adjusted means revealed that patients in both conditions exhibited a stronger approach bias for nicotine-related than for tooth-cleaning images at pretest (nicotine AAT-bias: adjusted $M = 19$, $SE = 8$; tooth-cleaning bias: adjusted $M = -15$, $SE = 8$), $F(1,268) = 7.8$; $p = .006$; $\eta^2 = .03$. Furthermore, there was a non-significant decline in bias scores for nicotine-related pictures (adjusted *M(pre)* = 19, *SE* = 8; adjusted *M(post)* = 11, *SE* = 5), $F < 1$; $p = .412$, but bias scores for tooth-cleaning pictures increased significantly from pre-to posttest (adjusted *M(pre)* = −15, *SE* = 8; adjusted *M(post)* = 10, *SE* = 5), $F(1,268) = 6.14$; $p = .014$; $\eta^2 = .02$. As a result, approach biases for these two picture categories did not differ at posttest, $F(1,268) < 1$; $p = .850$; $\eta^2 < .01$. In contrast to our hypothesis, no significant three-way interaction between time, condition and picture category emerged, $F < 1$; $p > .921$. AAT bias scores per group are displayed in Fig. 1.

3.3. Clinical outcome

Our main clinical outcome was the change in daily nicotine consumption. Mauchly-Test indicated that the assumption of sphericity was violated, $\chi^2(2) = 13.46$; $p < .001$. Therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .95$). There was a significant interaction between condition and daily nicotine consumption, $F(1.89,253.22) = 3.21$; $p = .045$; $\eta^2 = .02$. Analyses of simple effects on the adjusted means revealed a reduction of nicotine consumption in both groups (AAT-training: adjusted *M(pre)* = 23.57, *SE* = 1.24, adjusted *M(post)* = 19.83, *SE* = 1.25, adjusted *M(follow-up)* = 17.01, *SE* = 1.38; $F(2,133) = 30.15$; $p < .001$; $\eta^2 = .31$; sham-training: adjusted *M(pre)* = 24.93, *SE* = 1.32, adjusted *M(post)* = 22.35, *SE* = 1.32, adjusted *M(follow-up)* = 21.52, *SE* = 1.43; $F(2,133) = 8.85$; $p < .001$; $\eta^2 = .12$). As indicated by pairwise comparisons, there was a reduction in nicotine consumption from pre- to posttest (AAT-training: $p < .001$; sham-training: $p = .003$) and from pre- to follow-up (AAT-training: $p < .001$; sham-training: $p = .002$) both in the AAT-training and sham-training group. Moreover, only the AAT-training group showed a continued reduction regarding the number of daily smoked cigarettes from posttest to follow-up ($p = .009$). Groups did not differ in the number of smoked cigarettes at pre-, $F(1,134) < 1$; $p = .459$; $\eta^2 = .001$, or posttest, $F(1,134) = 1.89$; $p = .172$; $\eta^2 = .01$, but a significant group difference emerged at follow-up, $F(1,134) = 4.96$; $p = .028$; $\eta^2 = .04$ (see Fig. 2).

Since the observed AAT-training effects on nicotine consumption were rather small (see effect sizes), and given the variability in AAT-training effects, we sought to determine whether training effect on smoking behavior would increase if only successfully trained participants were considered in the analysis (see Wiers et al., 2010; for a similar approach). To this end, we performed an explanatory analysis with a subsample of patients showing a nicotine-bias decrease from pre- to posttest (patients in the AAT-training condition who became faster at pushing nicotine) versus patients not showing this intended bias decrease (patients in the AAT-training condition who did not show a change in action tendencies or even became faster at pulling nicotine). Thus, analyses were only performed with patients allocated to the AAT-training condition. In this group, 31 patients showed the intended bias decrease (difference between post- and pretest nicotine-bias <0), whereas a bias decrease could not be measured for 42 patients (i.e., difference between post- and pretest nicotine-bias ≥0). The 2 (group: successfully versus non-successfully trained) × 3 (assessment time: pre, post, follow-up) ANOVA revealed a significant main effect of time on daily smoked cigarettes, $F(2,70) = 22.2$; $p < .001$; $\eta^2 = .39$, indicating a decrease in nicotine consumption as a result of time. However, the interaction between condition and time was insignificant, $F(2,70) < 1$; $p = .92$; $\eta^2 = .02$, suggesting that training efficacy did not have an additive effect on smoking behavior.

The effect of condition on changes in several variables related to smoking was tested with a mixed MANOVA. Results showed a

Table 1
Demographic, smoking-related and psychiatric sample characteristics.

Variable	AAT-training (N = 73)	Sham training (N = 66)	p
Age (years)	43.30 (9.69)	41.97 (11.11)	.452
Gender (% female)	26	27	.868
Education level[a]	2.82 (1.44)	2.31 (1.57)	.06
Duration of nicotine consumption (years)	25.71 (10.40)	23.36 (10.48)	.186
Number of daily smoked cigarettes (pre)	23.38 (10.14)	24.98 (10.95)	.374
Number of prior quit attempts	2.80 (4.47)	3.28 (12.24)	.755
Medication (% of users, mainly anti-craving)	17	22	.191
Primary diagnosis			.756
% substance-use disorders	63	61	
% mood disorders	18	17	
% anxiety disorder	4	0	
% no acute disorder (crisis intervention)	1	0	
% no diagnostic interview achieved	14	23	
Number of comorbidities	1.14 (1.13)	1.49 (1.54)	.173
Psychiatric unit			.712
% detoxification	75	74	
% rehabilitation	23	23	
% depression	2	3	
Number of completed sessions	4.63 (.84)	4.42 (1.09)	.194

Note: Continuous variables were analyzed using univariate ANOVAs, $F(1,137)$; categorical variables were analyzed using chi-square-tests. All p-values are two-tailed. Standard deviations are given in parentheses.
[a] Education level was scored on a scale ranging from 0 (primary school) to 5 (university degree).

Table 2
Summary of pre- and posttest smoking-related variables and effects of time and condition.

Variables	Group					
	AAT-Training		Sham Training		Time	Condition
	Pretest	Posttest	Pretest	Posttest	p	p
Craving	1.82 (1.35)	1.57 (1.16)	2.18 (1.61)	1.23 (1.26)	<.001	.912
FTND[a]	5.62 (2.10)	5.12 (2.28)	5.86 (2.11)	5.23 (2.26)	<.001	.638
Smoking attitude	-.88 (.81)	−1.11 (.85)	-.83 (.92)	−1.07 (.87)	<.001	.771
Motivation to quit[b]	.91 (.75)	1.13 (.77)	.87 (.75)	.91 (.73)	.078	.255
Abstinence goal[c]	3.38 (1.50)	3.57 (1.21)	3.08 (1.66)	3.47 (1.31)	.006	.411
Desire to quit	7.45 (2.33)	7.90 (2.15)	6.86 (2.88)	7.69 (2.67)	<.001	.346
Expected success in quitting	5.18 (2.33)	6.14 (2.21)	4.31 (2.44)	5.74 (2.61)	<.001	.105
Difficulty in quitting	7.40 (2.07)	7.10 (1.95)	7.94 (1.97)	7.25 (2.06)	.015	.267
Valence rating (smoking)	4.25 (1.96)	3.61 (1.84)	4.16 (2.13)	3.41 (2.04)	<.001	.655
Arousal rating (smoking)	4.57 (1.38)	4.46 (1.49)	4.57 (1.95)	4.18 (1.94)	.142	.588
Craving rating (smoking)	4.63 (2.14)	3.74 (2.07)	4.84 (2.36)	3.48 (2.26)	<.001	.952
Valence rating (tooth-cleaning)	6.72 (1.91)	6.62 (2.01)	6.75 (2.38)	7.09 (2.23)	.408	.478
Arousal rating (cleaning)	4.13 (1.72)	3.76 (1.54)	3.69 (2.17)	3.13 (2.03)	.006	.073

Note. Variables were analyzed using a 2 × 2 ANOVA, $F(1,120)$. All p-values are two-tailed. Standard deviations are given in parentheses.
[a] FTND = Score in Fagerström Test for Nicotine Dependence [22].
[b] Within the range of 0 (not motivated to quit) and 2 (motivated to quit within the next 30 days).
[c] Within the range of 0 (no goal) and 5 (total abstinence, never use again).

significant main effect of time, $F(13,108) = 6.19$; $p < .001$; $\eta^2 = .43$. Separate univariate ANOVAS on outcome measures revealed a decrease in craving, $F(1,120) = 23.23$; $p < .001$, nicotine dependence as measured with the FTND, $F(1,120) = 20.75$; $p < .001$, and expected difficulty of quitting, $F(1,120) = 6.15$; $p = .015$, a more negative attitude toward smoking, $F(1,120) = 13.21$; $p < .001$, a more negative subjective evaluation of smoking pictures, $F(1,120) = 23.33$; $p < .001$, and less reported craving in response to smoking pictures, $F(1,120) = 35.41$; $p < .001$, over time, irrespective of condition. In addition, patients in both experimental groups reported at posttest an increase in their abstinence goal, $F(1,120) = 7.88$; $p = .006$, desire to quit, $F(1,120) = 14.35$; $p < .001$, and expected success in quitting, $F(1,120) = 38.61$; $p < .001$. The interaction between condition and time was non-significant, $F(13,108) = 1.08$; $p = .42$; $\eta^2 = .12$. Therefore, this effect was not followed back with univariate tests or discriminant function analyses. Table 2 displays an overview of pre- and posttest smoking measures per group.

3.4. Mediation by change in nicotine approach bias

We investigated whether change in the nicotine approach bias mediated the link between treatment condition and the main treatment outcome (reduction in daily smoked cigarettes from pretest to follow up). Bootstrapped results indicated that the total effect of condition on reduction of nicotine consumption was significant, $b = 2.56$; $p = .049$, suggesting that belonging to the AAT-training condition led to a higher reduction in nicotine consumption (in line with results from the 2 × 3 ANCOVA reported above). In addition, the direct effect of condition on reduction of nicotine consumption when accounting for differences in bias change did not reach significance, $b = 2.52$; $p = .053$. Most importantly, the indirect effect of condition on reduction of nicotine consumption through bias change was non-significant, $b = .04$, *BCa CI* [-.21; .32], $\kappa^2 = .003$, 95% *BCa CI* [0; .01]. Thus, there was no support for a mediation effect by change in nicotine approach bias.

Explanatory subsample-analyses using successfully versus non-successfully trained participants allocated to the AAT-training

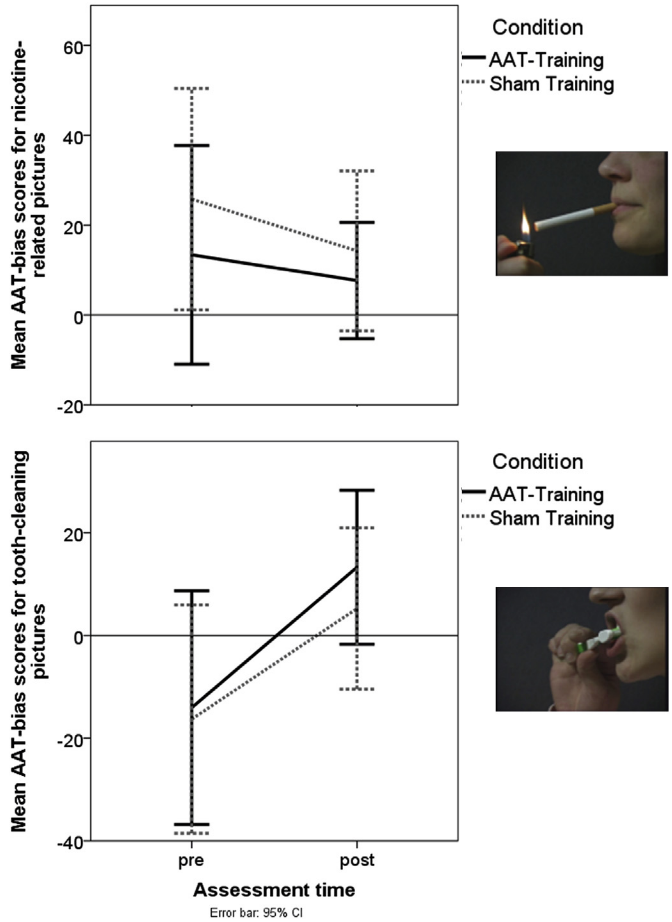

Fig. 1. AAT bias scores on the assessment AATs for the AAT-training and the sham-training group. Error bars represent the 95% confidence interval.

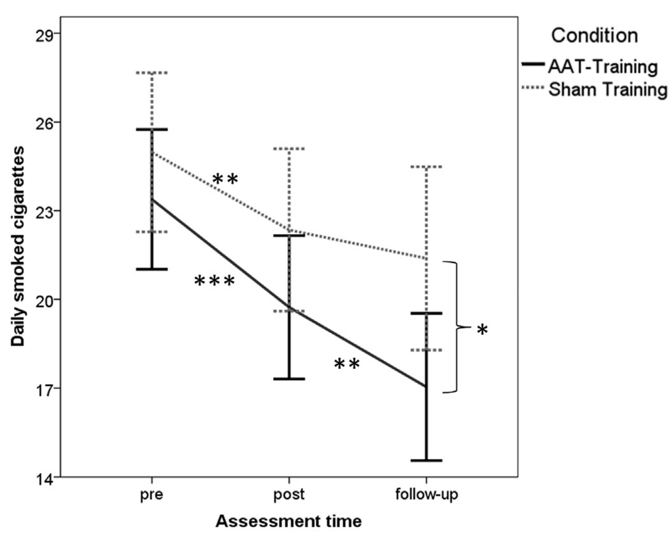

Fig. 2. Daily smoked cigarettes at pretest, posttest and three-months follow-up for the AAT-training and the sham-training group. *p < .05; **p < .01; ***p < .001 (two-tailed). Error bars represent the 95% confidence interval.

group (see above) also indicated that the indirect effect of condition on reduction of nicotine consumption through bias change was non-significant, $b = -1.54$, *BCa CI* [−4.05; 1.41].

4. Discussion

Using a multi-session CBM, the present study provides preliminary support that AAT-training might reduce nicotine consumption in a very challenging group of smokers during inpatient psychiatric care. Our finding contributes to the growing body of research on CBM approaches to the treatment of mental disorders, and substance-related disorders in particular (Eberl et al., 2013; Schoenmakers et al., 2010; Wiers et al., 2011; Wittekind et al., 2015). Our study extends previous alcohol-retraining CBMs by demonstrating training effects in non-abstinent drug-users. In addition, only the AAT-training group, but not the sham-training group, showed a continued decrease in nicotine consumption from posttest to follow-up. However, note that this decrease — although statistically significant — was rather modest. This outcome dovetails with findings from alcohol-AAT re-training, which showed therapy effects even at one-year follow-up (Eberl et al., 2013; Wiers et al., 2011). Thus, an AAT-training could be a feasible adjunct to traditional smoking interventions. This finding is notable, given that despite the devastating effects of tobacco smoking on health, nicotine dependence is the most common addiction disorder and is specifically frequent in the mentally ill (Grant et al., 2004). Despite frequent reluctance to treat nicotine addiction in psychiatric settings, Prochaska and colleagues (2014) showed that tobacco cessation treatment for psychiatric inpatients led to a decreased rehospitalization risk. Therefore, we believe that it is absolutely essential and worthwhile to provide psychiatric patients with a smoking intervention, and that AAT-training could be a promising part of this intervention.

The present study replicated our former result that smokers show an automatic approach bias toward nicotine cues (Machulska et al., 2015). However, we did not find a nicotine-bias decrease as a consequence of AAT-training and there was no support for a mediation effect through change in nicotine-approach bias. Several explanations might account for this outcome. First, contrary to the AAT re-training studies conducted with alcoholic inpatients (Eberl et al., 2013; Wiers et al., 2011), smokers in the present study were neither motivated nor explicitly instructed to abstain from tobacco smoking for the time of their participation. Presumably, continued nicotine consumption and being surrounded by nicotine cues could have constantly triggered the approach-oriented system, thereby countering the training effect induced by the AAT. This possibility deserves further scrutiny, and future studies should examine the effect of continued consumption versus abstinence on change in drug-related cognitive biases.

Second, given that trainings were accompanied by an additional smoking cessation intervention, similar nicotine-related and tooth-cleaning biases in both training groups could be a result of this smoking intervention. Specifically, the objective of the smoking intervention was to transfer knowledge about tobacco smoking, contribute to the understanding of the development and maintenance of nicotine dependence, and encourage patients to identify and adopt strategies that allow them to abstain from tobacco smoking in high-risk and habit-like situations. With regard to dual-process models described earlier (Wiers et al., 2013a), such a smoking intervention might have strengthened the regulative system which is believed to be rather weak in long-term drug users. Since this smoking intervention was administered both in the AAT-training and sham-training group, strengthened regulative processes might have equally affected bias scores in these groups, and by doing so, could have undermined group differences. Indeed, there is some evidence that indirect measures such as the AAT are sensitive to effects of cognitive behavioral therapy (Reinecke et al., 2012). Moreover, both training groups reduced the number of consumed cigarettes from pre-to posttest and improved on several explicit smoking-related variables, such as attitude toward smoking and motivation to quit, which also endorses the assumption that the smoking intervention improved regulative processes. Most importantly, however, the AAT-training was more effective in reducing long-term nicotine consumption than the sham-training, indicating that avoidance training had an additional positive effect on the patients.

Several limitations have to be considered. First, we did not include an objective measure of nicotine consumption (i.e., measurement of carboxyhemoglobin levels). Hence, information concerning the number of consumed cigarettes could have been prone to social desirability effects. However, this is true for both training groups and cannot explain the additional reduction observed in the AAT-training group. Moreover, abstinence was not a set expectation. Thus, smokers had relatively low motivation to misreport their smoke intensity at follow-up. Also, a brief training evaluation at follow-up indicated that training acceptance was rather high, irrespective of whether the AAT-training or the sham-training was conducted. Also, patients in both conditions assumed the training to be somewhat effective in reducing smoking, suggesting that social desirability effects, if existent, might have had a comparable effect in both versions of the AAT training. Second, apart from the number of smoked cigarettes, we did not measure other explicit smoking-related variables at follow-up. It remains uncertain whether – as with nicotine consumption – there would have been a delayed training effect on more controlled processes. Third, the AAT-training did not only train smokers to avoid cigarettes but also to approach tooth-cleaning images. Hence, training effects could be attributable to nicotine-avoidance, to tooth-cleaning-approach training, or to the interaction of both. Future studies should incorporate more differentiated experimental designs in order to dissect the exact mechanisms by which the AAT exerts its influence on addictive behaviors. Forth, albeit patients were blind to experimental conditions, due to the course of the study, the assessor was not (single-blind trial). Finally, although there was an increased reduction of consumed cigarettes in the AAT-training group, from a clinical perspective, this effect was rather modest.

Future studies should investigate whether the multi-session AAT re-training influences smoking intensity or abstinence rates in healthy smokers, and whether the AAT is capable of reducing relapse rates after smoking cessation. In fact, some studies already undertook similar attempts with some promising results (Macy et al., 2015; Wittekind et al., 2015). However, these results must be interpreted with extreme caution because the studies conducted so far have serious methodological deficits (e.g., single-session design, no measurement of pre- and post-test approach tendencies, outcome measures not directly associated with smoking behavior). Hence, we urgently need methodologically sound trials to produce conclusive long-term results and to elucidate the mechanisms underlying the AAT training.

To summarize, our encouraging results are novel and point to the efficacy and feasibility of the nicotine AAT re-training for reducing nicotine consumption in a very challenging sample of psychiatric smokers with various states of motivation to quit. The AAT training has the advantage not only to train smokers to avoid nicotine, but provides an alternative behavior to be approached (here: tooth-cleaning). Another evident advantage of the AAT is its easy administration. In fact, the AAT can be easily delivered online with an opportunity to complete sessions at home, and evidence exists that CBM also works over the web (Wiers et al., 2015). This paves the way for implementing the nicotine-AAT training as an adjunct to traditional smoking cessation programs.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jpsychires.2015.11.015.

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