ADDICTA: THE TURKISH JOURNAL ON ADDICTIONS

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ISSN 2148-7286 ♦ **eISSN** 2149-1305
http://addicta.com.tr/en/
DOI 10.15805/addicta.2019.6.3.0047 ♦ 2019 ♦ 6(3) ♦ 567–610

Submitted: August 2, 2018 **Revision Requested:** September 15, 2018
Accepted: November 27, 2018 **Last Revision Received:** February 23, 2019

Research Article

The Effects of Negative Mood Manipulation on the Attentional Bias of Smoking and Nonsmoking Young Adult Males

Emel Kalınkılıç[1]
University of Health Sciences

Zeynel Baran[2]
Hacettepe University

Abstract

The aim of this study is to determine the effects of an experimentally induced negative mood on cigarette smokers' cravings and attentional bias toward smoking-related visual stimuli using the Visual Dot Probe Task (VDPT). Forty smoker and 40 nonsmoker male participants (18-30 years old) were randomly assigned into negative mood and neutral/control conditions. Before the mood induction manipulation (MIM), participants' emotional state was measured with the Mood-State Adjective Pairs List (MSAPL) as pre-test scores. The MIM was then applied by presenting instrumental music and International Affective Picture System (IAPS) photos with negative valences at the same time for 3 min 22 sec. The control group, however, received only neutral IAPS photos without any music for the same duration in negative MIM. Afterwards, all groups were subjected to VDPT, then the MSAPL was reapplied for obtaining the post-test scores. Next, to determine the change in smokers' willingness to smoke, the Smoking Craving Scale (SCS) was applied, and for their dependence levels, the Fagerström Test for Nicotine Dependence (FTND). Lastly, positive mood induction was applied only to participants exposed to the negative MIM for ethical concerns. Measurements, *d'* prime scores based on signal detection theory, and reaction times related to the correct responses for VDPT were analyzed using the 2(Group: Smoker, Nonsmoker) x 2(Mood State: Negative, Neutral) x 2(Relationship: Smoking-related, Smoking-unrelated) mixed ANOVA. The SCS indicates an increase in the desire for smoking to exist after exposure to the smoking-related stimuli. Comparison of the pre- and post-MSAPL scores reveals the negative MIM to be successful. According to the VDPT analyses, smokers reacted more accurately and quickly to smoking-related pictures than nonsmoking-related ones. Thus, smokers are more likely to process smoking-related stimuli faster and to show an attentional bias toward them. No such finding exists for nonsmokers. Smoking-related stimuli create an attentional bias for smokers, reflecting a change in their cognitive processes. Though negative mood boosts that bias, being exposed to smoking-related stimuli is more effective on smoking desire and, thus, on craving than negative mood.

Keyword

Nicotine • Cigarette • Dependence • Attentional bias • Negative mood • Mood induction • Signal detection theory

* This is an extended abstract of the paper entitled "Olumsuz Duygudurum Değişimlemesinin Sigara Kullanan ve Kullanmayan Genç Yetişkin Erkeklerde Görülen Dikkat Yanlılığı Üzerindeki Etkileri" published in *Addicta: The Turkish Journal on Addictions.*

1 **Correspondence to:** Emel Kalınkılıç, Gülhane Vocational School of Health, University of Health Sciences, Etlik, Ankara Turkey. Email: emelkc@gmail.com

2 Department of Psychology, Faculty of Letters, Hacettepe University, Çankaya, Ankara 06800 Turkey. Email: znbaran@hacettepe.edu.tr

To cite this article: Kalınkılıç, E., & Baran, Z. (2019). The effects of negative mood manipulation on the attentional bias of smoking and nonsmoking young adult males. *Addicta: The Turkish Journal on Addictions, 6,* 567–610. http://dx.doi.org/10.15805/addicta.2019.6.3.0047

Tobacco consumption is among the factors that are not contagious but that create high risk of death according to records from the World Health Organization (WHO) and Turkey (T.C. Sağlık Bakanlığı, 2015; WHO, 2016). Cigarettes are an important cause of death and of several diseases both for smokers and passive smokers. When compared to other abused substances, cigarettes have a greater potential for addiction and, despite all the precautions (such as raising prices and placing negative stimuli on cigarette packages), are still used by smokers because of nicotine addiction (Benowitz, Hukkanen, & Jacob, 2009; Kanıt & Keser, 2010). A better understanding of the factors (causes) that contribute to smoking can lead to preventing smoking and provide us with opportunities to develop new practices, thus gaining new perspectives on its treatment. This is an important step for public health, as smoking addiction is a preventable health problem.

Research on cigarette consumption has mainly focused on the neuropsychopharmacological effects of nicotine and other chemicals in cigarette smoke. Research has attempted to figure out the interactions of these effects within different areas such as learning, personality traits, social environment, and genetics to understand the factors that determine cigarette consumption and factors that keep one addicted. Though much research has been conducted about this topic, the exact reasons for cigarette consumption have not yet been fully explained. Cigarettes have been claimed to affect sensory and motor abilities through the central nervous system and differentiate cognitive processes, especially learning, attention, and memory (Besson & Forget, 2016; Grundey et al., 2015; Rocha & Reis, 2015; Heishman, Kleykamp, & Singleton, 2010; Koob & Le Moal, 2007; Sutton, Van Rensburg, Jentink, Drobes, & Evans, 2016; Swan & Lessov-Schlaggar, 2007; Zhang et al., 2016). However, a debate exists on whether this differentiation is good or bad. While the majority of studies have shown smoking to have positive effects on cognitive processes, other studies exist showing just the opposite, that smoking also deteriorates cognitive processes.

Attention is one of the most important cognitive processes affected by smoking. Despite attention having many different definitions, it can be defined as the classification of appetitive or aversive stimuli through a mechanism (Franken, 2003), as concentration of mental effort on sensory or intellectual events (Solso, Maclin, & Maclin, 2009), as a brain process that controls and regulate information processing (Tsotsos, 2011), as a selective process (Carrasco, 2013), or as a process of directing one's mental sensors to stimuli that occur in the vicinity of which the individual is able to access and be aware of through sensory organs (Eysenck & Keane, 2000).

An organism is exposed to an unlimited number of stimuli at any time in its living environment. However, it does not have the capacity to process each stimulus to which it is exposed. Due to this limitation in the processing capacity, an organism has to make a choice among the stimuli being exposed to and select only the most relevant and necessary one. By allowing this selection to be done, attention provides the organism to act in a targeted way (Franken, 2003). Through attentional processes, the organism can distinguish between important or insignificant information for itself, ignoring insignificant stimuli by giving priority to the selected stimuli (Akyürek et al., 2012). In these aspects, attention is an indispensable precondition of perception, thinking, learning, remembering, and all types of conscious processes.

Attentional bias is defined as a bias for detecting and processing in favor of one stimulus by giving attention to that stimulus which is important for the person (Waters et al., 2009). In other words, attentional bias can be explained as a person's tendency toward objects and events associated with one's personal life (Miller, 2013). This tendency shows itself as a decline in reaction time (i.e., increase in reaction speed) to that stimulus.

A substance-related attentional bias has also been observed in addiction. According to Franken's (2003) Integrated Model, which explains people's cravings and relapse processes, this bias can affect addiction behavior in three ways. First, attentional bias increases the likelihood of detecting substance-related cues in the environment. This automatic selection process is responsible for detecting substance-related cues much more easily. Perceiving cues about a substance has been known to depend on conditional responses, known as craving and trigger relapse. Second, when a cue is detected, that cue is processed automatically and disengaging attention from the cue gets harder and harder. Increased attention focused on substance-related cues can trigger more explicit cognitive processes like positive expectations and thoughts about a substance. In turn, these cognitive processes can cause cravings. Thirdly, due to the limited capacity of attention, focusing automatically on substance-related cues may interfere with, and thus cause failure in, processing alternative cues.

Similarly, Robinson and Berridge's (1993) Incentive-Sensitization Model of Drug Dependence and Baker, Piper, McCarthy, Majeskie ve Fiore's (2004) Affective Model of Drug Motivation claim that substance-related cues gain motivational value and through this way are perceived as attractive and desirable. Thus, craving and attentional bias to substance-related cues will be increased in addicted people. The models argue that these processes occur automatically at the early stages of stimulus processing and progress beyond awareness.

Negative mood has an effect on cigarette consumption motivation and relapse. According to the Affective Model of Drug Motivation, addicted people learn to suppress their negative mood by using substances (Baker et al., 2004). Thus smoking behavior, in accordance with negative reinforcement, will increase in frequency to eliminate the effects of unpleasant/aversive situations. Empirical studies indicate that cigarette consumption and negative mood are strongly related to each other (Conklin & Perkins, 2005; Parrott & Garnham, 1998; Willner & Jones, 1996; Vinci, Copeland, & Carrigan, 2012), and relapse rates are higher in people with increased negative affect (Kodl et al., 2008; Shiffman et al., 2007). Many studies have found evidence supporting the relationship between nicotine addiction and negative mood when investigating smoking urges in adults (Carmody et al., 2012; Greenberg et al., 2012; Kahler et al., 2010).

In the light of all this information, this study aims to investigate the effects of experimentally induced negative mood on smokers' cravings and attentional bias toward cigarette-related visual stimuli using the Visual Dot Probe Task (VDPT).

In this context, the hypotheses of the study are:

H_1: Participants assigned to the negative mood condition and to the neutral mood condition will differentiate from each other in terms of their Smoking Request Scale scores.

H_2: Participants who are assigned to the negative mood condition and those assigned to the neutral mood condition will be differentiated in terms of their Mood-State Adjective Pairs List (MSAPL) scores.

H_3: Participants' MSAPL scores will vary depending on whether they smoke cigarettes and on which mood induction group they are in.

H_4: The VDPT performances of the participants will vary depending on whether they smoke cigarettes, on experimentally generated mood induction manipulation, and on the extent to which the pictures have a relationship with cigarette smoking.

Method

Research Group

The study is conducted with 80 young adult male participants working in Gülhane Medical Faculty (accidental sampling), and their ages ($N = 80$, $\bar{X} = 24.39$, $SD = 2.39$) range between 18-30 years old. To control the possible confounding effects of gender, only male participants were invited to the study. The non-smokers group ($n = 40$, $\bar{X} = 24.43$, $SD = 2.34$) consists of participants who reported the number of cigarettes used throughout their life did not exceed 100, and the group of smokers ($n = 40$, $\bar{X} = 24.15$, $SD = 2.46$) consists of people who've smoked for at least 1.5 years and smoked at least 10 cigarettes daily for the last 6 months. All participants have normal or corrected normal visual acuity and normal or corrected normal auditory levels. Participants have no problems with color vision, are right handed, and have no reported alcohol or substance addiction history. In addition, having any history of psychiatric-neurological diagnosis, related drug usage, and getting a BDI score greater than or equal to 17 are the criteria for exclusion from the study. Ethics committee approval was obtained from both institutions for the study.

Data Collection Tools

Demographic information form (DBF). This form has several items concerning the sociodemographic characteristics for the participants, such as participant code, date of application, age, marital status, gender, educational status, hand preference, visual acuity, monthly income, color vision, and general health status. The form also has questions related to history and pattern of smoking.

Fagerström Test for Nicotine Dependence (FTND). This test was developed by Fagerström for evaluating the physical intensity of nicotine addiction (Heatherton, Kozlowski, Frecker, & Fagerström, 1991). The test contains six items, and the highest and lowest scores that can be taken from the test are 10 and 0. This test was applied only to the nonsmokers in the study.

Mood-State Adjective Pairs List (MSAPL). The MSAPL is a 7-point Likert-type scale with 72 adjective pairs (Er, 2006). For each pair of adjectives, participants are asked to evaluate their current mood by giving a score between 1 (most positive) and 7 (most negative). In pre-test and post-test applications, increases in the post-test score relative to pre-test score are considered an indication of negative change, as in this study.

Beck Depression Inventory (BDI). The BDE is used to measure participants' levels of depression symptoms and evaluate whether or not they could be included in the study (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The form of inventory used in this study is the Beck Depression Inventory adapted and standardized to Turkish culture by Hisli in 1989.

Ishihara Color Blindness Test (ICBT). This is used to determine whether participants have problems with color vision and to evaluate quickly whether they could be taken into the study or not (Melamud, Hagstrom, & Traboulsi, 2004). The ICBT is the most effective test for diagnosing congenital red-green disorder among other pseudo-isochromatic tests. In the study, not all 24 pages of the test were applied, only the first four pages were shown to the participants.

Smoking Craving Scale (SCS). This is a single-item 10-point Likert-type scale for determining changes in smoking craving. The participant is required to compare his/her current smoking craving level with a time before the application of the scale. If the participant's craving for smoking did not change, "0" should be marked; if increased, a value between +1 and +5; and if decreased, a value between -1 and -5 should be marked accordingly on the scale (Sayette et al., 2000).

Visual Dot Probe Task (VDPT). MacLeod, Mathews, and Tata (1986) first developed the task. In the computer version of the task where cigarette-related stimuli are used, two pictures are presented side by side on the screen simultaneously. While one of those pictures is substance (cigarette smoking) related, the other is not. After these pictures disappear from the screen, the target stimulus (i.e., a dot symbol) appears on a location where one of the pictures was previously presented (either on the left or on right). The participant is asked to mark the location of the dot by pressing the "X" and "M" keys on the keyboard, as quickly and accurately as possible. The fastest response time shows the attentional bias for these events when the target is changed within a certain event class. Detailed information for the task is given in the procedural section below.

Pictures used in the study. Pleasant, unpleasant, and neutral pictures used in the study have been selected among pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Another characteristic of those selected pictures is that their power to induce positive and negative mood have been shown by studies done in Turkey (Arıkan, 2012; Çılgın, 2015; Kılıç, 2007).

Music used in the study. In the study, music with negative valence has been used to induce negative mood in half the participants. At the end of the experimental sessions for those participants, instrumental music pieces with positive valence (violin) were listened to for eliminating the effects of the negative mood induction (Sezgin, 2015). Using a 7-point Likert scale, statistics related to the valence and arousal levels ($N = 10$) of the musical pieces are: Segah Taksim – piece number 4, mean valence = 2.5, $SD = 1.43$, mean arousal = 4.50, $SD = 1.71$; Şehnaz Longa – piece number 10, mean valence = 5.50, $SD = 1.27$, mean arousal = 5.30, $SD = 1.16$.

Procedure and Data Collection Process

A signed informed consent form was taken prior to the experimental session for each participant. Later, the ICBT and BDI were applied. People with color blindness and/or BDI scores ≥ 17 were excluded from the study.

In the first stage of the study, the MSAPL was applied to determine participants' mood state levels before the experimental manipulation (pre-measurement). Next, mood induction manipulation was done as follows. Participants in the Negative Mood State condition were both played a negative musical piece (Segah Taksim - piece number 4) and shown pictures chosen from IAPS with a negative valence (Arıkan, 2012; Çılgın, 2015). However, participants in the Neutral Mood State condition were only shown neutral pictures (Arıkan, 2015; Çılgın, 2015). Negative and Neutral Mood State conditions were kept equal in terms of experimental manipulation duration (3 min 22 sec), and the number of stimuli presented (36 pictures). The size of each picture presented is 27.5 x 15.5 cm, and each picture is presented for 5000 ms.

Between pictures, a focusing "+" sign with 48 pt. Courier New Font is presented for 500 ms (see Figure 1).

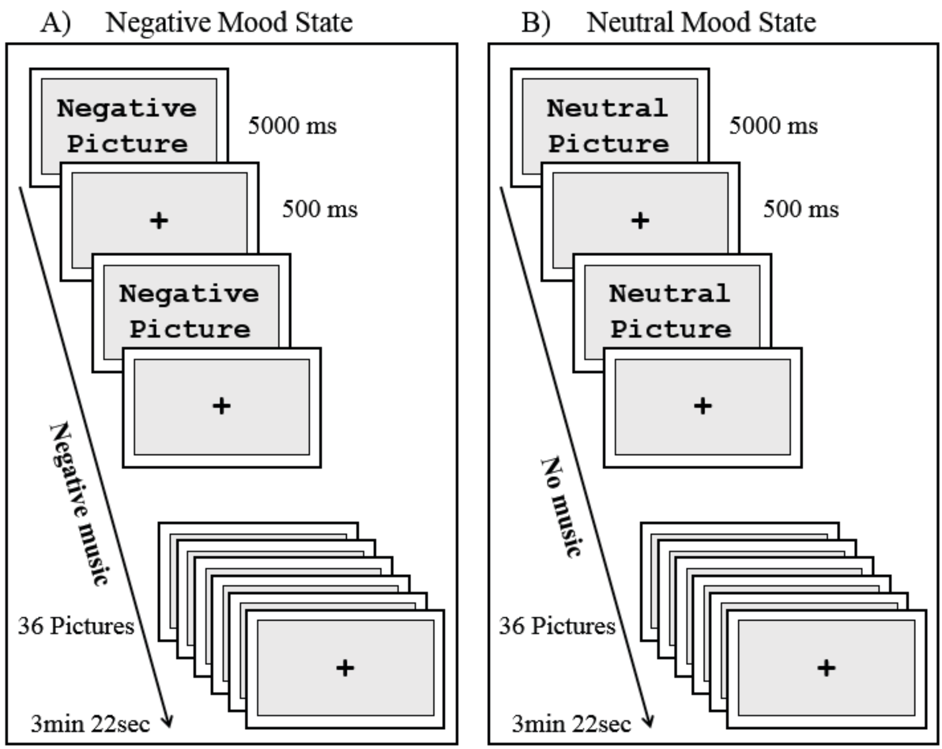

Figure 1. Mood induction manipulation: the negative (A) and the neutral (B) mood state conditions. In the negative mood state condition, a negatively rated musical piece is presented along with a negatively valenced pictures. However, no music is presented in the neutral mood state condition.

The study was conducted in a quiet, well-lit room reserved for this work, using a 15.6-inch laptop and a standard headset. The loudness level of the music pieces was kept at the same level for each participant. The distance of the participants to the computer screen was set at 60 cm.

In the second part of the experiment, all participants had the Visual Dot Probe Task (e-prime version 2.0, Psychology Software Tools). The task consists of 20 smoking-related and 20 nonsmoking-related pictures, a total of 40. The pictures are presented in pairs to the left and right of the "+" sign, and only one of the pictures that make up the pair relate to smoking in each trial. All participants are given a practice session with the pictures not used in the original study.

One part of the experiment, having a total of 80 trials, is as follows. Firstly, a "+" sign is presented in the middle of the screen for a 1000 ms duration to have the participant focus on this point. Next, a picture pair is shown for 500 ms. One image of the pair is presented on the right and the other image on the left of this "+" sign. After that, the picture pair is removed from the screen while the "+" sign remains on the display for another 500 ms. Then, a black dot with a diameter of 1 cm appears on the center of where one of the previously seen pictures had been, either on the right or the left of that "+" sign, for 2000 ms. The participants' task is to determine the location of the black dot that immediately followed the pair of pictures by pressing either "M" (for the dot on the right side) or "X" (for the dot on the left side) key as soon as possible. The "+" sign used in the task is presented with 70 pt. Courier New Font; each picture's area on the screen is 8.5 x 7.5 cm. The task related parameters are based on the study by Mogg and Bradley (2003).

Each of the pictures that make up a picture pair (smoking-related and nonsmoking-related) are presented a total of four times to counterbalance the spatial position of the dot that follows the pair such that each picture is presented twice on the left of the screen and twice on the right. Thus, when the nonsmoking-related picture is shown on the left of the screen, the spatial location of proceeding dot is on the left in one trial and on the right for the other trial. The same rule applies to the smoking-related pictures as well. Therefore, each stimulus pair has four trial types (see Figure 2). The presentation order of the image pairs is randomized, but the spatial location of the pictures and proceeding dots are counterbalanced.

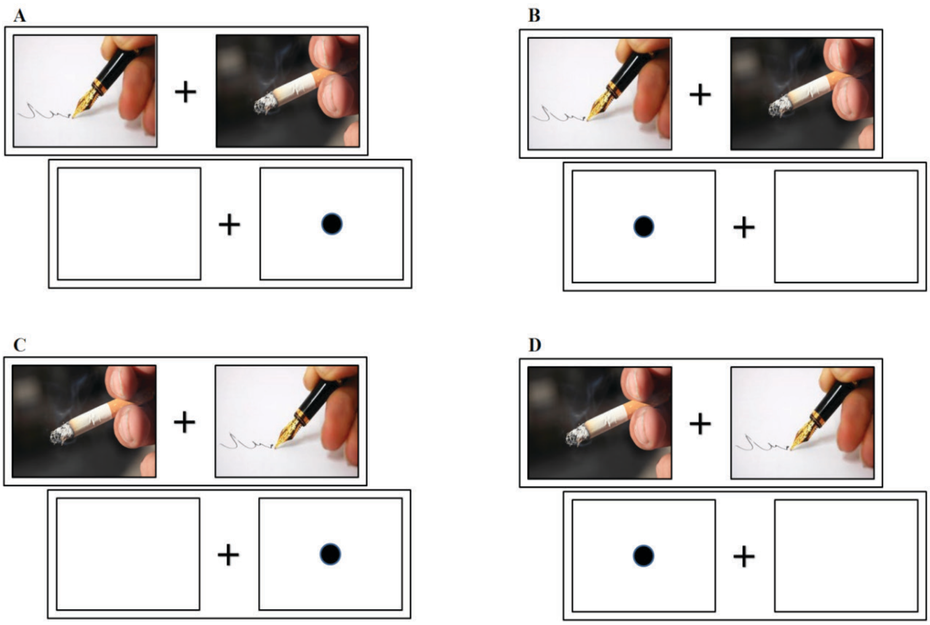

Figure 2. The visual dot probe task: A) The condition where the smoking-related picture is on the right and the dot following is also on the right. B) The condition where the smoking-related picture is on the right, however, the dot that follows is on the left. C) The condition where the smoking-related picture is on the left, however, the dot following is on the right. D) The condition where the smoking-related picture is on the left as well as the following dot. If the position of the dot is considered according to the nonsmoking-related picture in the pair, then the four conditions are also formed from a different stand point.

Later, the MSAPL is given a second time (post-test measurement) as a manipulation check to determine the effectiveness of the mood induction manipulation. In the smoking group, the SCS and FTND are applied to determine the change in their smoking cravings.

In accordance with ethical principles, positive mood induction is applied in the third and last stage of the study to those participants who had previously been subjected to negative mood manipulation to return their negative mood into a positive one. The pictures used in this section are the same as the pictures shown in the negative mood condition in terms of time, number and size; they have a positive valence and have been selected from IAPS. While the pleasant pictures are being presented, a musical piece with positive valence (Şehnaz Longa, piece number 10) is also played in the background. The experimental procedure can be seen in Figure 3.

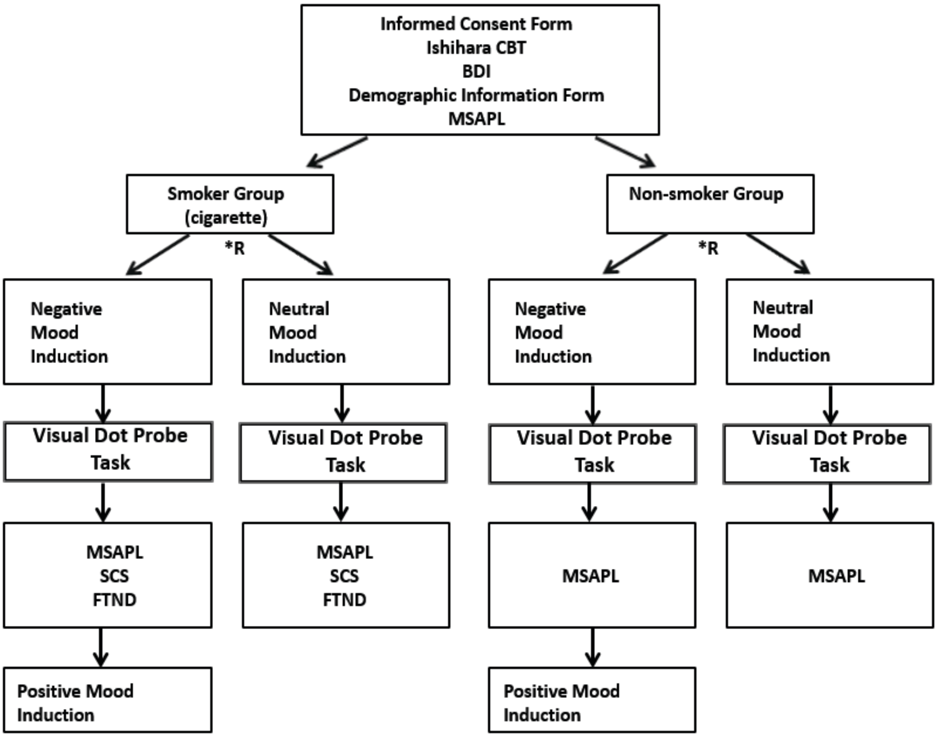

Figure 3. Procedure and process schema for scales and tasks used in the study. *R: random assignment of participants into groups.

Findings

The study has two groups: cigarette smokers ($n = 40$) and non-smokers ($n = 40$). In total, there were 82 participants, but two participants' data have been excluded from analyses due to having BDI scores greater than or equal to 17. In the statistical analyses (SPSS 22), when assumptions for the tests are not met, results for the non-parametric equivalent of the tests are reported, and Bonferroni corrected results are reported in the *post hoc* comparisons.

Analyses Related to FTND Data

The FTND means for the negative and neutral mood states of the smokers have been compared through the independent group *t*-test. According to this, no significant difference is found between smokers' negative mood state FTND mean score ($\bar{X}$ = 4.90, *SD* = 2.90) and smokers' neutral mood state FTND mean score ($\bar{X}$ = 3.65, *SD* = 2.70, $t_{(38)}$ = 1.41, $p > .05$). Thus from the perspective of nicotine dependency levels, the two groups (smokers in negative mood state, and smokers in neutral mood state) are similar.

Analyses Related to SCS Data

In the smoking group, the SCS scores for the negative and neutral mood states have been compared using the Mann-Whitney U test. Accordingly, the SCS scores for smokers in the negative mood condition (*M* = 2) was significantly higher than the SCS scores of smokers in the neutral mood condition (*M* = 0), *U* = 44, *z* = -4.51, *p* = .000, *r* = 0.71). Therefore, the smoking craving/desire for smokers in a negative mood state is higher than the smoking craving/desire for smokers in the neutral mood state.

Analyses Related to MSAPL Data

As a manipulation check to determine whether the mood state induction manipulation had worked or not, the MSAPL pre- and post- measurements have been analyzed using the 2(Group: Smoker, Nonsmoker) x 2(Mood State: Negative, Neutral) x 2(Time: Pre-test, Post-test) mixed ANOVA with the repeated measure as the last factor. The means and standard deviations related to this analysis are given in Table 1.

Table 1
The MSAPL Means and Standard Deviations with Respect to Group and Mood State Variables

		Time			
		MSAPL Pre-test		MSAPL Post-test	
Group	**Mood State**	$\bar{X}$	***SD***	$\bar{X}$	***SD***
Smoker	Negative	2.33	0.95	3.25	1.06
	Neutral	2.78	0.94	2.81	0.95
Nonsmoker	Negative	2.61	0.88	3.42	1.04
	Neutral	2.57	0.92	2.57	0.92

Note. MSAPL: Mood-State Adjective Pairs List, $\bar{X}$: Mean, *SD*: Standard Deviation.

According to analyses, while only the Time main effect and Mood State x Time interaction effect are significant, other main and interaction effects are not.

When examining the means from the MSAPL with respect to the levels for Time, the post-test MSAPL mean ($\bar{X}$= 3.01, *SE* = 0.11) is significantly higher than the pre-test MSAPL mean ($\bar{X}$ = 2.57, *SE* = 0.10; $F_{(1, 76)}$ = 87.60, *p* = .000, η^2_p = 0.54). Thus, participants got higher MSAPL scores on their second evaluations relative to their first evaluations, meaning they showed their tendency toward the more negative adjectives in the adjective pairs.

The significant Mood State x Time interaction effect ($F_{(1, 76)}$ = 82.96, *p* = .000, η^2_p = 0.52) has been examined using the Bonferroni-corrected *post hoc* comparisons. Accordingly, while no significant difference is found between the neutral mood state group's pre-MSAPL ($\bar{X}$= 2.68, *SE* = 0.15) and post-MSAPL ($\bar{X}$= 2.69, *SE* = 0.16) scores, a significant difference between the negative mood state group's pre-MSAPL ($\bar{X}$ = 2.47, *SE* = 0.15) and post-MSAPL ($\bar{X}$= 3.34, *SE* = 0.16) scores (*p* =.000, *r* = 0.83). Therefore, though the pre- and post-MSAPL scores are similar for the neutral mood state group, due to the experimental manipulation (negative picture and music presentation) done to the negative mood state group, adjective pairs were more negatively evaluated in the post-MSAPL application than in the pre-MSAPL application for this group.

Analyses Related to Visual Dot Probe Task Data

Responses recorded in the Visual Dot Probe Task were primarily classified into *Hit*, *False Alarm*, *Miss*, and *Correct Rejection* categories ın accordance wıth the signal detection theory. Due to the nature of the task, the number of responses in the miss category was very low (practically zero), and the number of responses in the correct rejection category was zero (as the participants should press a button on either the left or right side where the dot appears on the screen; no trial occurred where participants needed to press no key in order to make a correct response). Having empty cells for most of the miss category and for all of the correct rejection category, the *d'* scores have been computed as an index of sensitivity by adding 0.5 to all category values whatever their previous values were, including 0, as suggested by Macmillan and Creelman (2005, pp. 8–9).

After that, the *Hit Rate* and *False Alarm Rate* have been calculated according to the following formulas.

$$Hit\ Rate = \frac{Hit}{Hit + False\ Negative} \tag{1}$$

$$False\ Alarm\ Rate = \frac{False\ Alarm}{False\ Alarm + True\ Negative} \tag{2}$$

In the next step, the *d'* score for each participant is calculated using the "NORM.S.INV" function in Microsoft Office 2016. Thus, in the calculation process of the sensitivity scores in this study, by considering all the response categories of the signal detection theory, especially the Hit and False Alarm in this study, a composite sensitivity score (*d'*) has been computed.

$$z(Hit\ Rate) = \text{NORM.S.INV}(Hit\ Rate) \quad (3)$$

$$z(False\ Alarm\ Rate) = \text{NORM.S.INV}(False\ Alarm\ Rate) \quad (4)$$

$$d' = z(Hit\ Rate) - z(False\ Alarm\ Rate) \quad (5)$$

Thus, the *d'* scores produced for each participant are analyzed using the 2(Group: Smoker, Nonsmoker) x 2(Mood State: Negative, Neutral) x 2(Relationship: Smoking-related, nonsmoking-related) mixed ANOVA design with the repeated measure as the last factor.

Response time measurements based on correct responses are also analyzed with another 2 x 2 x 2 mixed ANOVA design with the repeated measure as the last factor.

Visual Dot Probe Task *d'* Analyses. Table 2 shows the mean and standard deviation for the *d'* scores related to Mood State, Group, and Relationship Status variables.

Table 2
Mean and Standard Deviations for the d' Scores on the Levels for Mood State, Group, and Relationship

Mood State	*Group*	*Relationship*	$\bar{X}$	*SD*
Neutral	Nonsmoker	Smoking-related	1.83	0.27
		Smoking-unrelated	1.83	0.22
	Smoker	Smoking-related	1.98	0.27
		Smoking-unrelated	1.93	0.22
Negative	Nonsmoker	Smoking-related	1.86	0.27
		Smoking-unrelated	1.95	0.22
	Smoker	Smoking-related	2.05	0.27
		Smoking-unrelated	1.85	0.22

Note $\bar{X}$: Mean, *SD*: Standard deviation.

When analyzing the means for the sensitivity index (*d'*) score given in Table 2 to test the hypothesis of the study (Table 3), smokers in the negative mood state responded more correctly to the dot following smoking-related pictures than following nonsmoking-related pictures (p = .017; also see Figure 4).

Table 3
Post Hoc Comparisons of Mood State x Group x Relationship Interaction Effect for Sensitivity Index (d') Scores

Mood State	*Group*	***Relationship*** **(a, b)**		***Diff.* (a-b)**	***SE***	***p* (*r)**
Neutral	Nonsmoker	Smoking-related (a) ($\bar{X}$= 1.828, *SE* = 0.06)	Smoking-unrelated (b) ($\bar{X}$= 1.829, *SE* = 0.05)	-0.001	0.82	.992 (0.00)
	Smoker	Smoking-related (a) ($\bar{X}$= 1.979, *SE* = 0.06)	Smoking-unrelated (b) ($\bar{X}$= 1.927, *SE* = 0.05)	0.051	0.82	.752 (0.07)
Negative	Nonsmoker	Smoking-related (a) ($\bar{X}$= 1.857, *SE* = 0.06)	Smoking-unrelated (b) ($\bar{X}$= 1.951, *SE* = 0.05)	-0.093	0.82	.257 (0.13)
	Smoker	Smoking-related (a) ($\bar{X}$= 2.048, *SE* = 0.05)	Smoking-unrelated (b) ($\bar{X}$= 1.848, *SE* = 0.05)	0.200	0.82	**.017** (0.27)

Note. **r* = effect size; Diff. = difference. Bonferroni correction was applied.

In addition, when examining Table 3 carefully (see *Diff.* column), though not significant, smokers are found to have a tendency to respond more correctly to the dot following nonsmoking-related pictures, while that response tendency changes in smokers such that they tend to respond more correctly to the dot following smoking-related pictures.

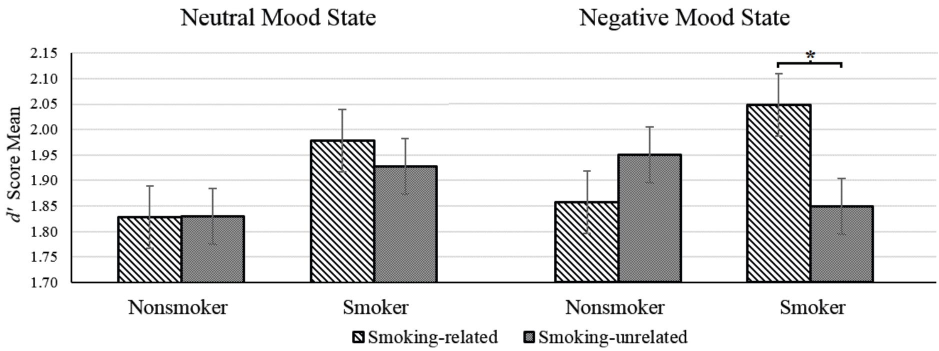

Figure 4. Looking at Mood State x Group x Relationship three-way interaction effect from the perspective of Relationship variable.

The same phenomenon observed in the three-way interaction effect above is valid in a basic way also for the Group x Relationship two-way interaction. When examining this effect, while smokers respond more accurately to the dot following smoking-related pictures ($\bar{X}$= 2.01, *SE* = 0.04) than nonsmokers ($\bar{X}$= 1.84, *SE* = 0.04; p = .007, r = 0.30), no significant difference is found in the accuracy of responses for the dot following nonsmoking-related pictures between the smokers ($\bar{X}$= 1.888, *SE* = 0.04) and nonsmokers ($\bar{X}$= 1.890, *SE* = 0.04; $p > .05$, r = 0.00), as seen in Figure 5.

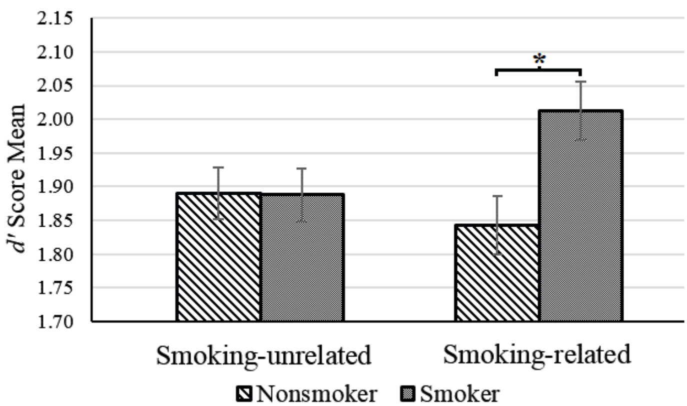

Figure 5. Group x Relationship interaction effect.

Analyses related to correct response times (ms) to the Visual Dot Probe task. Response time scores related to correct answers are analyzed with a similar 2 x 2 x 2 mixed ANOVA design as done for the *d'* scores in the above section. The means for correct response times related to this analysis are given in Table 4.

Table 4
Mean and Standard Deviations of Correct Response Time Scores (millisecond) at the Levels of Mood State, Group and Relationship Variables

Mood State	***Group***	***Relationship***	$\bar{X}$	***SD***
Neutral	Nonsmoker	Smoking-related	337.40	56.30
		Nonsmoking-related	342.64	77.37
	Smoker	Smoking-related	323.14	56.30
		Nonsmoking-related	434.95	77.37
Negative	Nonsmoker	Smoking-related	327.65	56.30
		Nonsmoking-related	326.98	77.37
	Smoker	Smoking-related	321.12	56.30
		Nonsmoking-related	444.02	77.37

Note $\bar{X}$: Mean, *SD*: Standard deviation.

Again, to test the study's related hypothesis, the Mood State x Group x Relationship three-way interaction effect has been evaluated from the perspective of Mood State. Accordingly, only participants in the smoker group responded more quickly to the dot following smoking-related pictures than to the dot following nonsmoking-related pictures (see Table 5).

Table 5
Post-Hoc Comparisons of Mood State x Group x Relationship Interaction Effect for Correct Response Time Scores (ms)

Mood State	***Group***	***Relationship* (a, b)**		***Diff.* (a-b)**	***SE***	***p* (****r*)**
Neutral	Nonsmoker	Smoking-related (a) ($\bar{X}$= 337.4, *SE* = 12.59)	Nonsmoking-related (b) ($\bar{X}$= 342.64, *SE* = 17.30)	-5.24	13.54	.700 (0.04)
	Smoker	Smoking-related (a) ($\bar{X}$= 323.14, *SE* = 12.59)	Smoking-unrelated (b) ($\bar{X}$= 434.95, *SE* = 17.30)	-111.81	13.54	**.000** (0.69)
Negative	Nonsmoker	Smoking-related (a) ($\bar{X}$= 327.65, *SE* = 12.59)	Smoking-unrelated (b) ($\bar{X}$= 326.98, *SE* = 17.30)	0.66	13.54	.961 (0.01)
	Smoker	Smoking-related (a) ($\bar{X}$= 321.12, *SE* = 12.59)	Smoking-unrelated (b) ($\bar{X}$= 444.02, *SE* = 17.30)	-122.90	13.54	**.000** (0.70)

Note. **r* = effect size; Diff. = difference. Bonferroni correction was applied.

In other words, while the quickest responses are those given by cigarette smokers to the dot coming after smoking-related pictures, the slowest responses are again those given by cigarette smokers to the dot coming after nonsmoking-related pictures (see Figure 6).

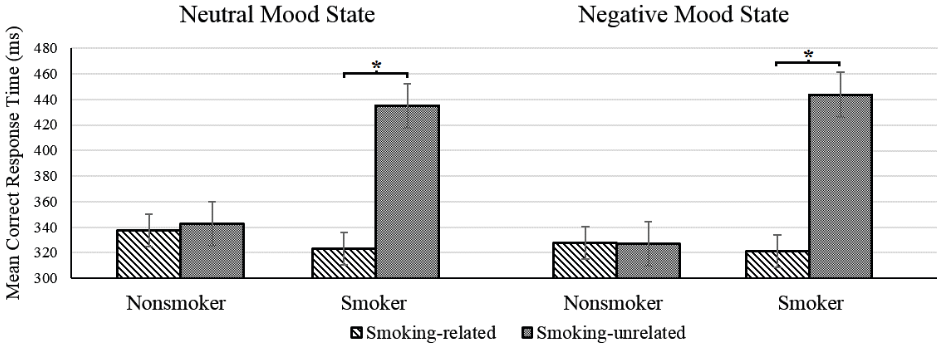

Figure 6. Three-way interaction effect of Mood State x Group x Relationship for correct response time scores (ms).

Moreover, the same phenomenon observed in the three-way interaction effect above is also seen in a more basic form for the two-way Group x Relationship interaction. When investigating this effect, while nonsmoking participants have no response time difference for the dot following a smoking-related ($\overline{X}$= 332.52, *SE* = 8.90) or a nonsmoking-related ($\overline{X}$= 334.81, *SE* = 12.23) picture; the smoking participants responded significantly more quickly to the dot following smoking-related pictures ($\overline{X}$= 322.13, *SE* = 8.90) than the dot following nonsmoking-related pictures ($\overline{X}$= 439.49, *SE* = 12.23; *p* = .000, *r* = 0.81), as seen in Figure 7.

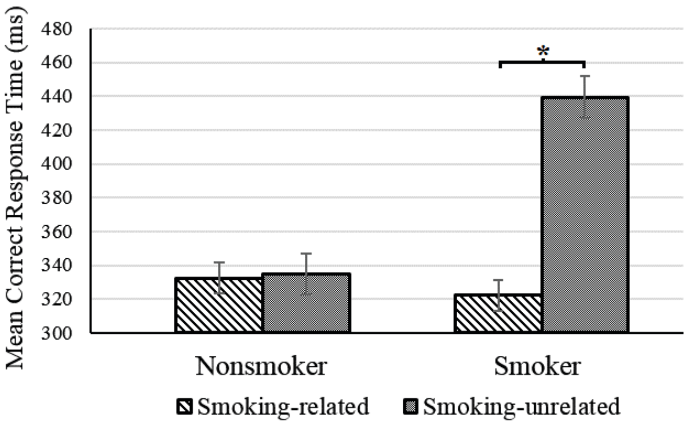

Figure 7. Group x Relationship interaction effect related to correct response time scores (ms).

Discussion

The aim of this study is to investigate the effects of experimentally induced negative mood on the desire to smoke (i.e. craving) and attentional bias to cigarettes related to visual stimuli in smokers using VDPT. For this aim, participants were first exposed to experimentally generated, negative and neutral mood state conditions, and then they completed the VDPT.

Evaluation of Findings Related to Fagerström Test for Nicotine Dependence (FTND)

No significant difference exists between the FTND mean scores for participants in a negative mood state with those for participants in a neutral mood state. Moreover, smokers in a negative mood condition had similar nicotine addiction scores as those in a neutral mood condition. Being the same in terms of smokers' nicotine addiction scores of smokers whether under negative or neutral conditions is very useful to control possible confoundings that might stem from pre-differences in addiction levels. Despite both groups being similar in their pre-addiction scores, the increase in the willingness to smoke in participants in the negative mood condition suggests that the factor that increases the desire is the negative mood state manipulation.

Evaluation of Findings Related to Smoking Craving Scale (SCS)

SCS scores for participants in a negative mood state are significantly higher than the SCS scores for participants in a neutral mood state. In other words, the desire to smoke (craving) is higher for participants in a negative mood condition. Therefore and in accordance with the literature (Vinci, Copeland, & Carrigan, 2012), an increase has been observed in the smoking-related craving scores for participants in a negative mood state as a result of mood state manipulation. Therefore, the hypothesis of the study, "Participants assigned to the negative mood condition and to the neutral mood condition will differentiate from each other in terms of their Smoking Craving Scale scores", was supported.

Evaluation of Findings Related to Mood-State Adjective Pairs List (MSAPL)

The MSAPL was used to control whether manipulations related to changing mood state had worked or not (i.e., for manipulation check). The hypothesis, "Participants who are assigned to a negative mood state and those assigned to a neutral mood state will differ in terms of their Mood-State Adjective Pairs List (MSAPL) scores" was tested by checking Mood State as the main effect. Despite the fact that the participants in a negative mood state had higher MSAPL scores ($\overline{X}$= 2.90, *SE* = 0.15) than those in a neutral mood state ($\overline{X}$= 2.68, *SE* = 0.10), it was not significant (p = .292, r = 0.12). Therefore, the hypothesis was not supported. However, perhaps with an increased number of participants, this difference might become significant. Hence, the power value (0.18) calculated for this comparison over the current number of participants in the study is much lower than the required value (0.80).

As the three-way interaction effect of Mood State x Group x Time was not significant, another MSAPL-related hypothesis, "Participants' MSAPL scores will vary depending on whether they smoke and in which mood induction group they are in," was examined by checking the two-way interaction effect of Mood State x Time. Accordingly, while no difference is found between the pre- and post-measurement

MSAPL scores for participants in the neutral mood state condition; due to the experimental treatment (mood induction by presenting negative pictures while listening to a negative musical piece), the participants in the negative mood state were observed to rate adjective pairs more negatively in their post-measurement ratings compared to their pre-measurement ratings. So, we think the reason behind the post-measurement scores being higher than the pre-measurement ones (on this scale, such a change implies negative evaluation) is the mood induction manipulation and not cigarette usage. In addition, the mean scores for the levels in the three-way interaction effect also support this result. Though the omnibus *F* test for three-way interaction effect was not significant, Bonferroni corrected comparisons related to Group x Mood State x Time was significant. This means that while no difference is found between the pre- and post-test scores of smokers and nonsmokers in a neutral mood state; when in a negative mood state, the significant difference between the pre-test and post-test scores for both smokers ($M_{diff.} = -0.924$, $p = .000$, $r = 0.75$) and nonsmokers ($M_{Diff} = -0.810$, $p = .000$, $r = 0.70$) indicates mood induction manipulation works and that manipulation creates a negative mood in the participants. On the other hand, not finding a significant difference between the pre- and post- MSAPL scores for smokers in a neutral mood state has caused us to conclude that being exposed to cigarette-related cues during the task did not have a negative effect on these participants. Therefore, this last hypothesis on the MSAPL was partially supported.

Evaluation of Findings Related to Visual Dot Probe Task Data

The Visual Dot Probe Task sensitivity index (*d'* scores) analyses revealed smokers in a negative mood state to respond more accurately to the dot following smoking-related pictures than nonsmoking-related pictures. In other words, while being in a neutral mood state, smoking-related pictures did not cause any effect in either smokers or nonsmokers, being in a negative mood state increased the number of correct responses only for smokers. This effect may be due to the fact that smoking-related stimulus draws more attention to itself and creates a readiness and response bias to the stimulus (dot mark) that followed the smoking-related stimulus; it needs to respond. Thus, observing only the smokers responding more correctly to the smoking-related stimuli reinforces the idea that response bias is a result from the addictive substances-related stimulus.

Signs indicating that smoking-related stimuli create an attentional bias in smokers become more evident when considering the results for the correct reaction time scores. Hence, the analyses of measurements related to reaction times for correct responses shows that while no time difference exist between the dot following the smoking-related or following the nonsmoking-related stimuli in the nonsmoker group, a significant response time difference exists for smokers both in the neutral and negative mood conditions such that the dot following smoking-related stimuli are responded to significantly more quickly than the dot following nonsmoking-related stimuli. Therefore, the substance-related stimulus increases the likelihood of both reacting correctly and rapidly to that substance-related stimulus. However, response-time related findings indicate that the smoking-related cues, rather than mood state, affect the bias mechanism more.

Therefore, using the correct response number and correct response time measurements, the attentional bias introduced at the behavioral level in the Visual Dot Probe task indicates a difference in the cognitive functions of the smoker group compared to the nonsmoker group. Thus, smokers' mean *d'* scores are significantly higher than the nonsmoker group's for smoking-related pictures (see Figure 5). In addition, the correct response reaction times of smokers to smoking-related pictures are lower than their correct response reaction times for nonsmoking-related pictures (see Figure 7). So, once both the number of correct response and correct response reaction time scores are evaluated together, a cognitive bias emerges for the processing of the substance-related clues compared to the processing of nonsubstance-related cues in smokers. That bias results in an enhancing-accelerating (boosting) effect on the processing of substance-related cues in the smoker group. This may be one of the factors underlying smoking motivation for smokers (Fisher, Knobelsdorf, Jaworska, Daniels, & Knott, 2013).

Many studies exist suggesting that cigarettes have an addictive effect via nicotine (Benowitz, 2010; Benowitz, Hukkanen, & Jacob, 2009; Picciotto & Mineur, 2014). These studies indicate nicotine to both affect the dopaminergic system, which is closely associated with addiction, and to bind to the nicotinic acetylcholine receptors of the cholinergic system in the brain. In addition to smoking dependence, the cholinergic system is also affected in many diseases such as Alzheimer's disease and schizophrenia and is also known to play important roles in the efficient fulfillment of various cognitive processes such as attention (especially selective attention), learning, and memory (Wylie, Rojas, Tanabe, Martin, & Tregellas, 2012). The processing efficiency for smoking-related stimuli (increase in the number of correct responses and decrease in reaction time) observed in smokers may be due to the fact that the neural networks of selective attention have better tuning/filtering to substance-related stimuli as nicotine also activates reward-related structures through dopamine.

Compared to nonsmokers, smokers had both more correct responses and thus less errors (as also indicated by higher *d'* sensitivity scores in the smoker group) in the VDPT. However, one should not conclude from this pattern that cigarette smoking has a positive effect on cognitive processes. In order to reach such a conclusion, the smoker group should have been divided into subgroups in terms of daily cigarette consumption and sensitivity scores should also show increase according to their smoking levels. On the other hand, even if such an impact could be mentioned, it is very clear that this effect is extremely negligible when considering the obvious negative effects of cigarette smoking on individual and public health.

The findings obtained in this study seem to be more compatible with Franken's (2003) *Integrated Model*, which describes the processes of craving and relapse in humans. Franken's model also suggests that subjective craving and attentional bias have a mutually stimulating relationship. Franken stated that, in the presence of substance-related clues, by the very automatic nature of the process, participants are unable to disengage their attention from substance-related clues or to engage their attention on nonsubstance-related stimuli, therefore, they ignore such kind of stimuli. As in this study also, smoking-related stimuli were the focus of attention and according to the results increased willingness to smoke. Increased willingness to smoke (craving), in turn, also increases attentional bias to smoking-related cues. Neglect of smoking-unrelated stimuli can be explained by the limited capacity of attentional system. Thus, due to that limited capacity, automatic focusing to substance-related clues may lead to failure of processing alternative hints (Franken, 2003).

Likewise, according to both Robinson and Berridge's (1993), *Incentive-Sensitization Model of Drug Dependence* and Baker et al.'s (2004) *Affective Model of Drug Motivation*, substance-related clues gain a motivational value in addicts. They are perceived as more attractive and more desirable and therefore they attract more attention. The findings related to correct response reaction times in this study support these views. Thus, enhanced attentional bias to smoking-related cues in turn may cause an increase in the search-find and craving behavior for these cues, making cigarette addicts more sensitive and fragile to stimuli that are more implicit for healthy people (Ehrman et al., 2002). Due to both the automatic and implicit nature of these processes, as well as the emergence of these processes in the very early stages of the stimulus processing, compared to smoking dependency, the institutions responsible for public health need to develop more effective policies that are both preventive and dissuasive for smoking. In addition, there must also be policies that discourage smoking.

As regarded by Ehrman et al. (2002) the Visual Dot Probe Task can be used as a tool for assessing the effectiveness of smoking cessation programs by assessing the attentional bias toward smoking-related stimuli in those people trying to quit smoking.

Limitations of the Study and Recommendations for Future Studies

The small sample size is one of the limitations of this study. With the increment of the sample size in the future studies, more powerful and more generalizable results will be attained. Also, in the study the time smokers had last smoked had not been controlled. Therefore, participants did not suffer from nicotine withdrawal, and they participated in the study at their desired level of nicotine. In future studies, looking at whether attentional bias has changed according to smoking deprivation and nicotine saturation may also be important.

The inability to match groups in terms of education and income level can be considered as a limitation. Instead of randomly assigning participants to mood state levels, matching those participants in terms of education and income level may be more effective in controlling confounding effects.

In Visual Dot Probe Task, the addition of pictures in which both the images shown on the right and left together are neutral, may be important to determine whether attentional bias is at level of engagement to stimulus or at the level of disengagement from stimulus.

Rather than taking a single measurement to determine the level of smoking desire or craving, participants might be asked how much they would pay for a cigarette at that moment, too. With questions such as how many cigarettes a person would use and how much they would pay, it may be possible to evaluate the drive in a more direct and quantitative way. Besides, to understand the attentional bias mechanism in addiction completely, physiological reflections of the processes related to bias should be also considered together with behavioral measures.

Acknowledgements

- The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
- The author received no financial support for the research, authorship, and/or publication of this article.

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