Journal of Experimental and Clinical Medicine
https://dergipark.org.tr/omujecm

Research Article

J Exp Clin Med
2024; 41(3): 485-490
doi: 10.52142/omujecm.41.3.6

Effects of smoking dependence level on attentional bias in smokers

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Received: 29.11.2023 • **Accepted/Published Online:** 03.07.2024 • **Final Version:** 30.09.2024

Abstract

There is uncertainty regarding whether the degree of nicotine dependence directly impacts the increase or decrease of attentional biases towards smoking-related cues. Their relationship remains unclear. Therefore, we compared the attentional bias among smokers with varying levels of dependence. We conducted the study with 114 smokers, utilizing a Modified Stroop Paradigm and Dot Probe Tasks to assess attentional biases toward both smoking-related and neutral cues. The objective was to compare attention bias levels among individuals with varying degrees of dependence. At various levels of nicotine dependence -whether mild, moderate, or severe- individuals demonstrated a consistent attentional bias towards smoking-related cues, suggesting no significant distinction between these groups. The results of the study show that there was no discernable correlation between attentional bias concerning smoking-related stimuli and the level of nicotine dependency. The results are discussed together with the existing studies.

Keywords: attentional bias, nicotine dependence, addiction, dot probe tasks

1. Introduction

Stimuli associated with addictive substances play a significant role in substance-seeking behavior (1). When users are exposed to cues related to the substance, it leads to various physiological changes such as increased heart rate, resulting in arousal and craving in individuals (2). Numerous theories related to addiction highlight the powerful impact of these cues in perpetuating addictive behavior and hindering attempts to quit (3, 4). It is known that this effect has a shaping influence on many cognitive processes, especially attentional functions (5, 6).

The phenomenon in which attention becomes disproportionately focused on a specific categorical stimulus over other stimuli is referred to as attentional bias (7). Attentional bias is also frequently observed among tobacco users (8–11), similar to alcohol (12), heroin (13) and cocaine (14) users. The studies have shown that the images or words related to smoking evoke thoughts of smoking, trigger the act of smoking (10) and lead to changes in brain neural activity (15). Additionally, research indicates that smokers exhibit a significant attentional bias towards smoking-related cues compared to non-smokers (16–18).

There are several prominent methods used in measuring attentional bias. The most commonly employed method is the visual probe test, also known as the dot-probe test (19). In this test, a pair of visual stimuli is presented on the screen for a specific duration, after which it disappears, followed by the presentation of a neutral cue, such as a "dot." Participants are instructed to rapidly indicate the direction of the cue using the arrow keys on the keyboard, and their responses are recorded at a millisecond level (20). Another method is the "Modified Stroop Test." Unlike the classic Stroop test, in this version, an addictive stimulus is presented in one of four colors, and individuals are asked to identify the color while disregarding the written word. If the Stroop effect is detected in the individual, it indicates a positive attentional bias (21).

There are several variables that can alter an individual's level of attentional bias towards addictive substances (5). One of these is the tendency for substance users to display attentional bias towards substance-related cues compared to neutral cues (22, 23). It has been observed that a similar effect is not present in non-users (24). Another crucial factor is cravings. Studies have demonstrated that craving increases an individual's attentional bias (5, 25, 26).

A review of the literature reveals that the level of substance use is associated with attentional bias (27, 28). The findings indicate that individuals heavily dependent on substances exhibit a greater focus on substance-related cues compared to those with mild addiction (29, 30). Similar results apply to cigarette smokers; however, unlike other addictive substances, both positive and negative correlations have been observed in these studies (31–34).

Considering international studies, there appears to be a

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scarcity of studies investigating the relationship between nicotine dependency levels and attentional bias. Similarly, no research on this subject has been conducted in our country. This circumstance highlights the original and innovative aspect of the current study, aimed at contributing to the literature and clinical practices.

The primary objective of this study was to ascertain whether there exists a noticeable distinction in attentional bias—a crucial cognitive effect implicated in perpetuating addiction—as the level of physiological dependence on cigarettes intensifies.

2. Materials and methods

2.1. Sample

The study was conducted in the psychology laboratory of Prof. Dr. Cemil Taşçıoğlu City Hospital between October 1, 2021, and October 1, 2022, spanning a duration of twelve months. Participants were recruited from outpatient clinics such as cardiology, internal medicine, and chest diseases, where individuals with high motivation for smoking cessation were presumed to be present, in addition to healthcare professionals like nurses, psychologists, and doctors. The inclusion criteria for participation consisted of individuals aged 18 to 65, with a minimum level of literacy, an expressed desire to quit smoking, and a score of 3 or higher on the Fagestrom Test for Nicotine Dependence. Participants were also required to volunteer with written consent. Exclusion criteria included any cognitive or physical impairment hindering the understanding and completion of tests, undergoing psychiatric diagnosis or treatment, having a history of or current severe neurological illness, and receiving smoking cessation therapy during the study period.

All procedures for the participants were conducted by the clinical psychologist (principal investigator). A total of 114 participants were initially engaged in the study. However, three individuals who made more than 30% errors in computer-based test applications (analyzed using the box and whisker plot method) and three participants with high levels of depression and anxiety were excluded from the study. Additionally, due to computer program errors, data from two participants were inaccessible. Three participants were excluded from the study as they scored less than 3 on the Fagerstrom Test for Nicotine Dependence. Thus, the analysis was based on data from a total of 103 individuals.

2.2. Process

The study was conducted in the psychology laboratory of the hospital. Volunteers who participated in the study were given appointments and were instructed not to smoke for at least 1 hour before the study. On the day of their appointment, after a brief assessment, they were taken to a room prepared in advance. All assessments were performed by investigator in charge. In sequence, the participants completed the "Sociodemographic Data Form," "Beck Anxiety Scale," "Beck Depression Scale," "Fagerstrom Test for Nicotine Dependence," "Questionnaire of Smoking Urges," "Visual Probe Test," and the "Stroop Test for Smokers." After the self-report scales were administered, participants were led to a dark room where two computer-based tests were conducted, concluding the study.

2.3. Scales

Sociodemographic Data Form: This is a form that examines sociodemographic information and smoking habits of the participants. The form was created by the researchers specifically for the study being presented.

Modified Dot-Probe Test/Visual Sign Test: A computerized visual probe test is used to assess attentional bias. During test, pairs of visual stimuli or words are presented horizontally side by side on the computer screen. These images remain on the screen for four different durations (200 ms, 500 ms, 1000 ms, and 1500 ms) before disappearing, followed by the appearance of a neutral cue (e.g., a dot) at the location of one of the previously displayed stimuli. Participants are then prompted to indicate the location of this cue using the arrow keys on the keyboard (20).

The visuals utilized in this study were obtained with special permission from "The Center for the Study of Emotion and Attention" at the University of Florida (35). Following appropriate pairings and evaluation by five experts, these visuals were included in the pilot study (18,36). A total of 12 appropriate smoking-related visuals and 12 neutral visuals were used in the study.

Smoking Stroop Test (SST): In the assessment of attentional bias, a modified Stroop test developed by Esra Kısacık and Zehra Çakır in 2019 for smoking-related cues was used. The test is designed to measure smokers' attentional bias towards smoking stimuli. Consisting of 9 neutral and 9 smoking-related verbal cues, this assessment tool 4 different colors similar to those in the classic Stroop test. All cues consist of words. Volunteers are instructed to press a button representing the color of the word as quickly as possible, regardless of the word's content, and their response time is recorded in milliseconds (37,38). The study found a Cronbach's alpha internal consistency coefficient of 0.78 for neutral cues (with item-total correlations ranging between 0.26 and 0.69) and a Cronbach's alpha of 0.83 for smoking-related cues (with item-total correlations ranging between 0.38 and 0.68) (38).

Fagerstrom Nicotine Dependence Test (FNDT***):*** The Fagerstrom Test for Nicotine Dependence (FNDT), which measures physical dependence on nicotine, consists of a total of 6 questions. An increase in the Fagerstrom score indicates an increase in an individual's physical dependence on nicotine. The test categorizes the degree of dependence into 5 groups: 'very low dependence,' 'low dependence,' 'moderate dependence,' 'high dependence,' and 'very high dependence' (39). The validation and reliability study of its Turkish version was conducted by Uysal and colleagues (Cronbach’s alpha = 0.56) (40).

Smoking Desire Inventory (SDI): An individual's desire to smoke is measured using a seven-point Likert scale. Scores range from a minimum of 10 to a maximum of 70. The validity and reliability of the scale, determined by a Cronbach's alpha value of 0.92 for the Turkish version, were established by Demirezen and Kurçer (41).

Beck Depression Scale: Beck introduced this assessment tool in 1961 with the aim of objectively identifying symptoms of depression. Its Turkish validity and reliability were examined by Tegin and Hisli, revealing correlation coefficients of r=0.80 and r=0.74, respectively (42).

Beck Anxiety Scale: This scale, developed by Beck in 1988 to assess anxiety symptoms, aims to objectively evaluate anxiety symptoms. Its Turkish validity and reliability were established by Ulusoy and colleagues (Cronbach's alpha = 0.93) (43).

2.4. Data Analysis

The study was analyzed using the SPSS 25.0 software. In the visual probe test, 103 participants generated 103 data sets, resulting in a total of 14,832 observation points. Prior to calculating central dispersion values for the observation data, erroneous entries, and responses below 200 ms and above 2000 ms, were excluded from the study (2%). The remaining data were transformed into z-scores, and observations exceeding three standard deviations were considered outliers and not included in the analysis (2%) (44).

Differences in terms of sociodemographic characteristics were evaluated using chi-square tests. The normality of the data sets was assessed using the Kolmogorov-Smirnov test, and checks were performed for kurtosis and skewness. One-way analysis of variance (ANOVA) was employed for comparisons involving three or more groups, with post hoc analyses, such as Tukey tests, being conducted to ascertain the differences between the groups. All statistical analyses were conducted with a significance level of $p<0.05$.

3. Results

Table 1 indicates that 64 participants (62%) were male, 46 (45%) were university graduates, and 62 (60%) were healthcare professionals. Among the participants, 25 (24%) were between the ages of 18 and 24, 36 (35%) were between the ages of 25 and 34, and 10 (10%) were between the ages of 35 and 44. Regarding sociodemographic characteristics, differences in distributions were observed in terms of age range and education level ($p<0.05$), while no significant differences were found in gender and reason for participation ($p>0.05$).

Table 2 indicates that 60 individuals (58%) initiated smoking before the age of 18, while 39 (38%) smoked for 1-10 years. The daily cigarette consumption for 39 participants (32%) ranged between 11-20 cigarettes. No significant differences were observed in the distributions of smoking habits based on the age range of smoking initiation and the amount of cigarettes consumed ($p>0.05$). Nevertheless, variations were observed in the distribution based on the number of years of smoking.

Table 1. Comparison of the distribution of participants' sociodemographic data

Sociodemographic Characteristics	n	%	X^2
Gender			
Woman	39	62	0.129
Male	64	38	
Education			
Primary School	11	11	0.006
Middle School	18	17	
High School	28	27	
University	46	45	
Age Range			
18-24 Years	25	24	0.008
25-34 Years	36	35	
35-44 Years	29	28	
45-54 Years	10	10	
55-64 Years	3	3	
Reason for Arrival			
Health Worker	62	60	0.566
Outpatient Clinic	41	40	

Table 2. The distribution of participants' smoking data

Cigarette Use Characteristics	n	%	X2
Smoking Starting Age			
Before 18 Years of Age	60	58	0.102
18-24 Years	43	42	
Year of Cigarette Use			
1-10 Years	39	38	0.003
11-20 Years	33	32	
21-30 Years	20	19	
31-40 Years	11	11	
Amount of Cigarette Use			
1-10 pieces	38	37	0.434
11-20 pieces	40	39	
21 Pieces and above	25	24	

Table 3 presents a comparison of the means of attentional bias in the visual probe test among the research groups. As indicated in Table 3, no significant differences were observed among the research groups ($p>0.05$).

Table 3. Descriptive and one-way ANOVA results based on the visual cue test for groups classified by the Fagerstrom Test for Nicotine Dependence

Variable	n	$\bar{x}$	σ	σ_M	F	p
Low Level	44	0.20	0.018	0.002	0.827	0.482
Moderate	16	0.022	0.017	0.004		
High Level	21	0.015	0.014	0.003		
Very High Level	22	0.23	0.019	0.004		

Table 4 presents a comparison of the means of the Smoking Stroop Test (SST) among the research groups. As indicated in Table 4, no significant differences were observed among the research groups ($p>0.05$).

Table 4. Descriptive and one-way ANOVA results based on the Smoking Stroop Test (SST) for groups classified by the Fagerstrom Test for Nicotine Dependence

Variable	n	$\bar{x}$	σ	σ_M	F	p
Low Level	44	0.22	0.020	0.003	0.618	0.605
Moderate	16	0.029	0.022	0.005		
High Level	21	0.021	0.019	0.004		
Very High Level	22	0.21	0.023	0.005		

Table 5 presents the descriptive and one-factor ANOVA results of the groups classified using the Fagerström Nicotine Dependence Test according to the SIAQ. Additionally, it presents the comparison of the means of the Smoking Desire Inventory among the research groups. The results indicate that there was no significant difference found among the research groups ($p>0.05$).

Table 5. Descriptive and one-way ANOVA results based on the Smoking Desire Inventory (SDI) for groups classified by the Fagerstrom Test for Nicotine Dependence

Variable	n	$\bar{x}$	σ	σ_M	F	p
Low Level	44	31.70	14.248	2.148	1.678	0.177
Moderate	16	39.75	15.847	3.962		
High Level	21	34.81	12.890	2.813		
Very High Level	22	39	18.989	4.048		

4. Discussion

The objective of the current study is to elucidate the influence of smokers' levels of dependence on attentional bias. The study found that the level of dependence among smokers did not significantly affect attentional bias or craving. In both the Smoking Stroop Test (SST) and the visual probe test, smokers exhibited a positive attentional bias, consistent with Tiffany's impulsivity theory related to substance dependence and Robinson and Berridge's addiction theory (26, 45). Nevertheless, no differentiation based on the level of dependence was observed in either test.

In previous studies on alcohol consumption, it has been observed that attentional bias varies based on the quantity of alcohol consumed (46–48). However, these studies employed a single cue onset asynchrony, and all cues remained on the screen for a similar duration. In contrast, our study featured stimuli (visuals) displayed for 4 different durations. Although numerous studies have indicated that variations in cue onset asynchrony among smokers are evident, there are also conflicting studies that assert the opposite (33, 49). This inconsistency makes it challenging to establish a causal relationship between cue onset asynchrony and other factors.

While some studies on other substances align with our findings (46, 50), the general consensus suggests that as the level of dependence increases, attentional bias also increases (27, 47, 51, 52). The variations in the parameters determining the level of dependence make direct comparisons between studies challenging (29, 47). In our study, the degree of nicotine dependency was determined based on the FNDT test, and a subset representing rare users and those with very low dependence was excluded from the analysis (39, 47). In our research, the categorization of groups based on physiological dependency enables us to reach objective conclusions.

The results of studies on cigarette users are more complex than those of studies on users of other substances. While some studies have indicated that smokers' attentional bias increases with higher levels of dependency (34, 53, 54), others have proposed that the attentional bias increases as dependency levels decrease (31, 32). Moreover, our research findings align with those of other studies that indicate that the level of dependence does not significantly impact attentional bias (16, 55). There could be several reasons for inconsistencies among studies. In our research, participants were instructed not to smoke for at least 1 hour before the assessment. Similarly, in other studies, participants were asked to refrain from smoking before assessments, yet there isn't a complete consensus on the impact of abstinence on attentional bias (31, 56). Another crucial aspect is the sample size; the participant count in our study is higher than that in other research. This circumstance complicates understanding the regression among levels of dependence. Due to this reason, it complicates our understanding of the relationship between levels of smoking dependence and attentional bias.

Studies indicate that as the level of dependence increases among cigarette users, cravings, motivation to quit smoking, and the quantity of cigarette consumption also increase (57). However, in our research, we observed no significant differences in cravings among the groups. While some studies with similar findings suggest that cravings do not directly impact attentional bias (55), conflicting research also exists that proposes otherwise (31).

It is known that individuals who continue to smoke exhibit a stronger attentional bias towards smoking-related cues compared to those who have quit (9, 55). Similarly, studies showing the effect of increased motivation to smoke on individuals' attentional bias (58). These findings collectively indicate that cigarette craving, smoking status, and motivation to smoke may have some effects on attentional bias towards smoking cues (31, 32). However, due to the absence of studies comparing the attentional bias and desire between individuals with smoking cessation motivation and those without, there is no clear evidence on whether the desire to quit smoking directly affects attentional bias and cigarette craving.

Contrary to expectations, the results indicated that there was no relationship between nicotine dependence levels among cigarette users and attentional bias towards smoking-related cues. The findings of this study, which was conducted with a larger sample size than previous research, are expected to contribute to further advancements in the field of research.

Ethical Statement

The ethics committee approval of the study was obtained from Istanbul Prof. Dr. Cemil Taşçıoğlu City Hospital Clinical Research Ethics Committee (Date: 13.09.2021; Decision No: 317) A signed consent form was obtained from each participant

in the study.

Conflict of interest

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript.

Funding

No funding was used for the study.

Acknowledgments

None to declare.

Authors' contributions

Concept: U.K., B.Ö., Design: U.K., B.Ö., Data Collection or Processing: U.K., B.Ö., Analysis or Interpretation: U.K., B.Ö., Literature Search: U.K., B.Ö., Writing: U.K., B.Ö.

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