ADDICTA: THE TURKISH JOURNAL ON ADDICTIONS

ISSN 2148-7286 • **eISSN** 2149-1305
http://addicta.com.tr/en/
2019 • 6(2) • 221–238

Extended Abstract

Investigating the Effects of Smoking and Cognitive Load Differentiation on Prospective Memory Performance*

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Abstract

Nicotine, the most harmful chemical found in cigarettes, is known to affect the cholinergic system and to alter cognitive processes such as attention and memory, especially sensory and motor activities; these effects vary depending on the level of cognitive load. Considering that smoking affects the brain structures associated with prospective memory, the effect on prospective memory performance is thought to possibly differ under different cognitive load conditions. Therefore, the main purpose of the present study is to compare the performance of participants in a time-based prospective-memory task under smoking and cognitive load conditions. When analyzing the data according to smoking condition, smokers are found to be quicker than non-smokers in terms of response time in the ongoing N-Back task. In addition, smokers have been found to make more prospective memory mistakes than non-smokers, especially under high cognitive load conditions.

Keywords

Prospective memory • Smoking • Nicotine • Cognitive load • N-Back task • Time-based prospective memory

* This is an extended abstract of the paper entitled "Sigara Kullanımı ve Bilişsel Yük Farklılaşmasının İleriye Dönük Bellek Performansına Etkisinin İncelenmesi" published in *Addicta: The Turkish Journal on Addictions.*

This work was presented as a poster at the 19th National Psychology Congress held in Izmir on September 5-7, 2016.

Manuscript Received: March 8, 2018 / **Accepted:** November 10, 2018 / **OnlineFirst:** April 15, 2019

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To cite this article: Pakyürek, G., & Şenyüz, L. (2019). Investigating the effects of smoking and cognitive load differentiation on prospective memory performance. *Addicta: The Turkish Journal on Addictions, 6,* 221–238.
http://dx.doi.org/10.15805/addicta.2019.6.2.0009

The main component of cigarette smoking is nicotine, which is responsible for long-term smoking through addiction and has been emphasized as an important tool in investigating the neurochemical foundations of cognitive processes (Watsins, Koob, & Markou, 2000). Nicotine is also known to affect the cholinergic system and to alter cognitive processes such as attention and memory, especially sensory and motor activities; its effects vary depending on cognitive-load levels (Ernst, Heishman, Spurgeon, & London, 2001b).

Prospective memory is remembering to do something in the future, the type of memory that remembers what has been planned (Henry, Rendell, Philips, Dunlop, & Kliegel, 2012). In other words, prospective memory includes the ability to remember actions or movements planned for a specific time in the future (Heffernan & O'Neill, 2012; McDaniel & Einstein, 2007).

Nicotine's effects on the frontal lobe and attention network may be related to time-based prospective memory, which uses resources from these regions. The brain regions and structures associated with prospective memory are known to be adversely affected by chronic smoking (Musso et al., 2007). Time-based prospective memory performance is more affected by these regions and structures of the brain in comparison to event-based prospective memory performance (D'ydewalle, Bouckaert, & Brunfaut, 2001).

For this reason, the study's main purpose is to investigate the effects of smoking on time-based prospective memory performance. The secondary aim is to investigate the effects of smoking on time-based prospective memory performance in cases with high and low cognitive loads.

Method

Research Design

The research is a laboratory based experimental study using ANOVA with 2 x 2 between-groups.

Research Group

94 undergraduate and graduate students (50 females and 44 males) from various faculties in Hacettepe University voluntarily participated in the study. Participants have been selected using the criterion sampling method. As a result, data from 66 participants have been found suitable for analysis. Of the participants, 31 are non-smokers (15 easy tasks, 16 difficult tasks) and 35 are non-smokers (19 easy tasks, 16 difficult tasks). The participants were randomly assigned to the ongoing task conditions. Prior to the study, no restriction was placed on how much smokers smoke. Participants participated in the experiment with their preferred levels of nicotine.

The participants' ages range from 18 to 28 with a mean age of 21.42 (*SD* = 2.00). The mean number of cigarettes smoked daily is 13.13 (*SD* = 5.30, *Range* = 7–25), and the mean Fagerström Nicotine Addiction Test (FNBT) score, which is used to measure smokers' addiction levels, has been calculated as 3.55 (*SD* = 2.51, *Range* = 0–9). Participants' mean Beck Depression Inventory score is 7.62 (*SD* = 5.06, *Range* = 0–16).

Data Collection Tools

E-Prime. E-Prime 2.0 is the computer software program that has been used for representing the presented letters. In addition, this program has also been used to record participants' response times and correct/false responses. The following tasks have been created using E-Prime.

N-Back Task. This is one of the most common tasks for measuring memory performance. The stimuli used in the N-Back Task consist of 23 uppercase letters written in white on a black background. These stimuli are presented randomly. The N-Back Task has been used for the ongoing task condition.

Time-Based Prospective Memory Task. Time-based prospective memory tasks are usually provided with a second, on-going task. In the current study, the participants were able to see the elapsed time in the response box at the center of the screen for 1000 ms when needed. The participants were asked to press a specific button in the response box after every two minutes, with a total of five time-based prospective memory tasks being created. Reactions given in the range of 10 seconds before or 10 seconds after the response are considered correct; responses given outside this time are considered incorrect.

Fagerström Test for Nicotine Dependence. The Fagerström test has been developed as a revised version of the Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978) for the purpose of determining participants' nicotine dependency levels. The Turkish version of the Fagerstrom Test for Nicotine Dependence is found to have moderate reliability (Cronbach's alpha = 0.56). This test was only applied to smokers.

Findings

The Mann-Whitney U Test has been used to compare the FNBT scores, duration of smoking, and number of cigarettes smoked daily through the type of tasks assigned to the groups. According to the results, cigarette-smoking participants in the easy and difficult task conditions have been found to not show a significant difference according to FNBT score, duration of smoking, or daily number of cigarettes (U = 481, $p > .05$, $\eta^2 = .01$; U = 477, $p > .05$, $\eta^2 = .01$; U = 485, $p > .05$; $\eta^2 = .01$, respectively). No significant difference exists between groups in terms of age or Beck

Depression scores ($U = 429$, $p > .05$, $\eta^2 = .03$; $U = 481$, $p > .05$; $\eta^2 = .04$, respectively). The response-time measurements for correct responses are found to be significantly different ($F_{(1,62)} = 4{,}612$; $p < .05$; $\eta^2 = .07$). The response times ($M = 569.19$, $SD = 78.50$) for smokers who responded to the correct response in the N-Back Task are significantly shorter than the non-smokers ($M = 609.11$, $SD = 71.36$). Also, the mean for smokers' false responses ($M = 1.71$, $SD = 1.3$) is significantly higher than non-smokers ($M = 1.00$, $SD = 1.2$).

Discussion

The analysis results show non-smokers to exhibit more prospective memory errors than non-smokers. Satıroğlu (2012) found no difference between smokers and non-smokers in terms of false responses. This finding contradicts the present study. However, given the fact that the present study is based on time-based prospective memory and that time-based prospective memory needs more resources for executive functions, smokers may be expected to make more mistakes than non-smokers.

Hicks, Marsh, and Cook (2005) found that time-based memory tasks used more working memory resources than event-based memory tasks. Similarly, Smith's (2003) theory of preparatory attention and memory processes suggests time-based prospective memory tasks need to use more resources from internal processes, leading to deterioration in both ongoing and prospective-memory tasks.

Waldeck and Miller (1999) found smokers to be more impulsive than non-smokers. The impulsivity and smoking use associated with the frontal region can be argued to increase the error rate of time-based prospective memory, which is similarly related to the frontal region. Smokers are more likely to make mistakes, considering that they use cognitive strategies in relatively difficult prospective memory tasks. In addition, smokers' shorter response times compared to non-smokers shows that they decide faster. For these reasons, the number of errors in the time-based prospective memory task is considered to be higher for smokers than non-smokers.

One of the main limitations of the study is that impulsivity is not controlled. Another limitation of the study is that the participants were determined as smokers or non-smokers based on their own statements with no physiological measurements being taken. Future studies can benefit from measuring addiction levels using physiological measurements to determine the levels of carbon monoxide, which is known to be sensitive to the amount of cigarette use. The effect of smoking on the time-based prospective memory performance is thought will be better understood by determining the present study's smoking levels through physiological measurements, by applying a more daily living task, by changing smokers' deprivation levels, and by controlling impulsivity.

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