

# Peak Provoked Craving After Smoking Cessation

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**Abstract.** Peak provoked craving (PPC) is an alternative approach to cue-induced craving that focuses on the highest craving level experienced during the exposure to drug-related cues. The main objective of this study was to assess the effect of abstinence on PPC in smokers and to determine whether PPC is altered by continuous abstinence. Results showed reductions on PPC levels only 24 hours after achieving abstinence and craving levels remain significantly lower after 7 days of abstinence.

**Keywords.** Peak provoked craving, Virtual Reality, smokers, treatment

## Introduction

Cue exposure studies have shown that smokers report craving increases during the exposure to cigarette stimuli compared to neutral stimuli under experimental conditions<sup>1</sup>. Such studies define cue-induced craving as the difference between pre- and post-exposure values. However, cue-induced craving has been shown to be moderate<sup>2</sup>. This may be due to high values of pre-exposure craving<sup>3</sup> when subjects are previously deprived (ceiling effect) or to low values of post-exposure craving in the case of satiated smokers (floor effect).

Peak provoked craving (PPC) is an alternative approach when measuring craving<sup>2</sup>. PPC focuses on the strongest craving level experienced during the exposure to substance-related stimuli, without subtracting pre-cue levels. PPC attempts to obtain a valid measure of user's urge for the substance without making a distinction between pre-exposure craving and cue-induced craving.

Despite nicotine deprivation has been strongly related with craving increases<sup>4</sup>, few studies have examined the effect of continuous smoking abstinence on craving levels. In the few studies that reported cue-induced craving levels after cessation, no abstinence effect was observed<sup>3</sup>. As the cue-induced approach may underestimate the effect of cue exposure on smokers, PPC could overcome this limitation.

The aims of this study were to analyze the effect of abstinence on PPC in smokers and to determine whether PPC is altered by continuous abstinence.

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## 1. Method

### 1.1. Participants

A total of 11 smokers (2 men and 9 women) participated in this study. Inclusion criteria for participation were aging 18 or older, smoking 10 or more cigarettes and be willing to quit. Participants involved in any other smoking cessation treatment and reporting any substance use disorder other than nicotine were excluded.

### 1.2. Instruments and measures

Sociodemographic characteristics and smoking history were assessed with a semi-structured interview.

The Fagerström test for nicotine dependence<sup>5</sup> (FTND) and the Nicotine dependence syndrome scale<sup>6</sup> (NDSS) were also applied. Carbon monoxide (CO) concentrations in expired air were measured at each session using the Micro-Smokerlyzer (Bedfont Scientific Limited, Rochester, UK). Abstinence criterion was  $CO \leq 4$  parts per million (ppm).

PPC was determined as the highest craving value reported by the participants during the exposure to a virtual environment. Craving was assessed every 2 minutes with a visual analogical scale (VAS) from 0 to 100 built into the virtual environments. PPC levels were measured before achieving abstinence, after 24 hours of abstinence and after 7 days of abstinence.

Virtual environments reproduce real-world settings where people smokes<sup>7</sup> and they were presented with an eyewear Vuzix iWear VR920 (Vuzix, Rochester, NY, USA) with 3 degree of freedom head tracker using a laptop computer running Microsoft Windows XP. Participants can also interact with the environments and rate self-reported craving levels by using a standard mouse.

### 1.3. Procedure

In each of the three sessions, participants provided a carbon monoxide sample in order to assess smoking status and they were exposed to Virtual Reality (VR) environments during a maximum of 30 minutes.

### 1.4. Statistical analysis

Descriptive analyses were performed with sociodemographic and clinical characteristics. A repeated-measures ANOVA (with Tukey's post-hoc comparisons) was conducted to determine whether levels of PPC differ across the three time points.

## 2. Results

Participants' characteristics at baseline are shown in Table 1.

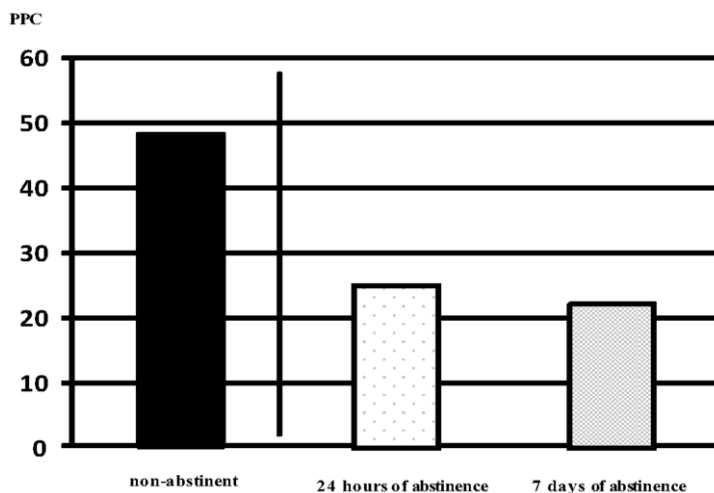
**Table 1.** Sociodemographic and clinical characteristics (n=11)

	Mean ± SD/%
Age	36.6 ± 15.6
Females (%)	81.8
Smoking duration (years)	15.4 ± 9.9
Cigarettes per day	14.7 ± 6.1
Nicotine per cigarette (mg)	.75 ± .07
FTND	3.1 ± 2.4
NDSS	55.2 ± 5.5
CO level (ppm)	10.5 ± 7.3

Note: FTND = Fagerström test for nicotine dependence; NDSS = Nicotine dependence syndrome scale; CO = Carbon monoxide; ppm = parts per million.

Figure 1 shows mean PPC level for each assessment: before achieving abstinence (M = 48.2; SD = 28.4), after 24 hours of abstinence (M = 25.1; SD = 23.2) and after 7 days of abstinence (M = 22.3; SD = 20.4). ANOVA results indicated that PCC differed significantly across assessments ( $F_{(2, 9)} = 4.95, p = .035, \text{partial } \eta^2 = .52$ ).

**Figure 1.** Peak provoked craving during virtual exposure session



Post-hoc comparisons showed that PPC before achieving abstinence was significantly higher than after 24 hours of abstinence and also after 7 days abstinence. No significant differences were found in PPC between 24 hours- and 7 days-duration of abstinence.

### 3. Conclusions

The main goal of this study was to assess the effect of smoking abstinence on PPC. The results showed that PPC decreased in abstinent smokers. The effect of continuous abstinence was observed on PCC levels after 24 hours of abstinence, and it was maintained after 7 days abstinence.

Craving use to be conceptualized as a conditioned response (CR) that may be eventually extinguished through repeated presentation of the conditioned stimuli (CS, specific contexts or persons related to tobacco use) without the unconditioned stimuli (US, tobacco use)<sup>8</sup>. Therefore, reductions in PPC may be explained for extinction processes as a result of the exposure to CS without smoking (response prevention) during the quitting and abstinence periods.

Cue-induced paradigm has been widely used in craving research<sup>1,3</sup>. Nevertheless, this approach has limitations to detect changes in craving when pre-exposure levels are influenced by abstinence effects. PPC could be an alternative measure of drug craving<sup>2</sup> as it detects overall effects of nicotine abstinence and cue exposure like the experienced by ex-smokers in everyday situations.

Limitations of the present study need to be mentioned. First, the small sample size may limit the generalization of our results. Second, despite 7 days of abstinence can be considered continuous abstinence, longer periods of abstinence need to be analyzed.

In summary, PPC was attenuated after achieving short- to medium-term abstinence, pointing to extinction processes related with exposure mechanisms. Our findings suggest that PPC is an alternative and complementary approach to assess tobacco craving that may contribute to understand the complexity of smoking craving.

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