

Psychophysiological Bases of smokers' Classification System Based on the Amazing Reflection of Tobacco-Related Rates*

Bases psicofisiológicas del sistema de clasificación de fumadores basado en el reflejo asombroso de las tasas relacionadas con el tabaco

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ABSTRACT

The psychological and sociocultural factors related to nicotine addiction have been described. This study aims to obtain psychophysiological bases of the Smoker Classification System, starting from the comparison of the startle reflex caused by tobacco-related cues in people with different levels of tobacco consumption. The startle reflex was recorded from a selected sample of 39 participants: 16 men and 23 women aged between 20 and 29 with a mean of 24.36 and standard deviation of 2.88. These participants smoked 5 to 15 cigarettes a day and had been classified using the Smoker Classification System's evaluation criteria based on questionnaire C4-R in which they were exposed to 21 images from the International Affective Picture System and to a startle sound stimulus of 105 dB. The electromyography of the *orbicularis oculi* was measured to evaluate the magnitude of the startle reflex. The topography of consumption and the results of the psychophysiological recordings were analyzed using comparative statistics of means through structural equation models. It was concluded that significant differences exist in the degree of physiological implication in all four consumption levels. Finally, the limitations and future directions of this study are analyzed.

Keywords

Classification; smokers; cigarettes; tobacco; startle reflex.

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RESUMEN

Se han descrito los factores psicológicos y socioculturales relacionados con la adicción a la nicotina. El objetivo de este estudio comparativo es obtener bases psicofisiológicas del Sistema de Clasificación de Fumadores a partir de la comparación del reflejo de sobresalto provocado por señales relacionadas con el tabaco en personas con diferentes niveles de consumo de tabaco. El reflejo de sobresalto se registró a partir de una muestra seleccionada de 39 participantes: 16 hombres y 23 mujeres de entre 20 y 29 años con una media de 24,36 y una desviación estándar de 2,88, que fumaban de 5 a 15 cigarrillos al día. Fueron clasificados mediante la evaluación Criterios del Sistema de Clasificación de Fumadores, basado en el cuestionario C4-R, en el que fueron expuestos a 21 imágenes del

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Sistema Internacional de Imágenes Afectivas y a un estímulo sonoro de sobresalto de 105 dB. Se midió la electromiografía del *orbicularis oculi* para evaluar la magnitud del reflejo de sobresalto. La topografía del consumo y los resultados de los registros psicofisiológicos se analizaron utilizando estadística comparativa de medias mediante modelos de ecuaciones estructurales. Se concluyó que existen diferencias significativas en el grado de implicación fisiológica en los cuatro niveles de consumo del sistema descrito. Finalmente, se analizan las limitaciones y orientaciones futuras de este estudio.

Palabras clave

clasificación; fumadores; cigarrillos; tabaco; reflejo de sobresalto.

Even though cigarettes are legal in just about every country of the world, they can turn into a dangerous habit affecting both the smoker and the people around them. According to the World Health Organization (WHO) (2020b), approximately 6 million people die each year from complications related to their current or lifelong smoking habits. More than 600,000 non-smokers are exposed to second or third-hand smoke. The Pan American Health Organization (PAHO) & World Health Organization (WHO) (2020) in 2014 predicted that the number of smokers in 2025 would reach 1.6 billion.

The direct health impact of cigarette smoking can be seen in the increase of risk of dying from diseases such as cancer, respiratory diseases (Herrera-Pamplona & Cogollo-Milanés, 2019; West, 2017; WHO, 2020a; WHO 2020b), the deterioration in mental health worldwide (Campo & Diaz, 2010; Corvalán, 2017), and the increase in drug use. The indirect impact of cigarette smoke can be seen in the harmful effects it has on non-smokers exposed voluntarily or involuntarily to second and third-hand smoke (American Addiction Centers, 2020; Azagba, 2015). Additionally, cigarette smoking causes economic and social losses (low productivity, workplace absenteeism, and accidents, family disputes, environmental pollution, fires, etc.) (WHO, 2020a).

However, most smokers cannot be classified as dependent, limiting the scope of the classification system proposed by the World Health Organization (Becoña & Lorenzo, 2004;

WHO, 2020b). Classification is based merely on cigarette count, while aspects such as intensity and the existence of related complications are ignored. Even the psychological and sociocultural factors related to nicotine addiction have been described more clearly. However, the psychological and social characteristics of people of different age groups and smoking habits have not been adequately studied.

Although the Smoker Classification System (SCS) proposed by Londoño et al. (2017), based on the Smoker Classification Questionnaire developed by Londoño et al. (2011), places smokers in four levels based on frequency, intensity and smoking-related complications, it is important to support the findings regarding the different characteristics of these levels with objective measures. One objective measure of dependence and withdrawal (which permits evaluating the physiological implications of nicotine) is the startle reflex; a part of the defensive reflexes that are affected by nicotine's core action on the reticular nucleus of the caudal part the bridge in charge of the startle motor (Bianchin & Angrilli, 2012; Gantiva et al., 2012; Gantiva et al., 2015; Leite et al., 2012; Rehme et al., 2009).

The startle reflex modulation is evaluated using images associated with tobacco-containing cues in the environment where people smoke and are linked to emotional factors (Shiffman et al., 2007). Environmental cues include physical conditions where smoking takes place (advertisements, waiting areas, public establishments, driving) and social cues (interaction with other smokers at social gatherings) (Teixeira do Carmo et al., 2005) that provoke more intense smoking in the individual.

This suggests differential activation of the appetitive motivational system according to the smoking level and nicotine dependence (Cui et al., 2012; Rehme et al., 2009). Therefore, the startle response is expected to be significantly different for the different smoking levels described in the SCS, confirming the characterization proposed by Londoño et al. (2017) in said system. Hence, this study's objective was to perform the differential

validation for each smoker level described in the SCS of Londoño et al. (2017) using the startle reflex caused by tobacco-related cues as a standard measure, previously validated by Gantiva et al. (2016) in the Colombian population.

Method

The following is a comparative study of which the objective obtains psychophysiological bases of the Smoker Classification System according to the smoking level, using as a reference the degree of physiological implications of nicotine expressed in the startle reflex. The comparative variable is the startle reflex in groups with different levels of tobacco consumption.

Sample

The sample selected through an initial interview was made up of 39 participants (16 men and 23 women) who smoked 5 to 15 cigarettes per day ($M = 7.44$), with a minimum educational level of high school and aged between 20 and 29 years ($M = 24.36$ and $DE = 2.88$). The comparison groups were formed from the score obtained in C4, and the first made up of 12 dependents, the second by 14 people with a high level of consumption, and the third with 13 consumers with a moderate level of risk (Table 1).

Table 1

Demographic information

| Variable | F | % |
|---------------------------------|-------|----|
| <i>Sex</i> | | |
| Men | 16 | 41 |
| Women | 23 | 59 |
| <i>Groups consumption level</i> | | |
| Moderate-risk | 13 | |
| Men | 2 | |
| Women | 11 | |
| Heavy smoker | 14 | |
| Men | 6 | |
| Women | 8 | |
| Dependent | 12 | |
| Men | 8 | |
| Women | 4 | |
| <i>Age</i> | | |
| Min. | 20 | |
| Max. | 29 | |
| <i>M</i> | 24.36 | |
| <i>SD</i> | 2.88 | |

The purpose of the interview was to verify that participants fulfilled the selection criteria such as:

- being smokers for at least one year.
- smoking at least 5 cigarettes a day.
- a period of self-reported abstinence of at least one hour.

Exclusion criteria consisted of: a medical history of head trauma, diagnosed neurological disorders, current pharmaceutical or psychiatric treatment, and untreated auditory or visual problems. The smoker level classification was created from the SCS that describes four smoking levels evaluated with the C4-R (Londoño et al., 2017).

Dependent. Smokers who experience withdrawal syndromes when they stop smoking are characterized by irritability, anger, impatience, tension, and anxiety. They have trouble controlling their habit even in places where smoking is explicitly and legally prohibited or when they are sick. Though they would like to quit, and on occasions, have had a relative,

friend or colleague asked them to do so, they have failed. Their consumption is over 20 cigarettes a day with more frequent inhalations to the lungs. The waiting time for beginning their daily consumption does not exceed 10 minutes after waking up in the morning.

Heavy smoker. Smokers with a high frequency of inhalation to the throat and some to lungs, smoking 10 to 19 cigarettes a day. Their first cigarette of the day can be postponed for 1 to 2 hours upon waking. Smoking has affected their lung capacity, which manifests in agitation and more frequent and intense colds, which has led to a health professional recommending quitting. The main smoking factors are associated with events that trigger anxiety.

Moderate-risk smoker. Smokers who have tried unsuccessfully to quit 2 to 4 times. Health problems are starting to manifest, albeit none are major. This person smokes even when sick.

Occasional smoker: Consumption of fewer than five cigarettes per week.

Instruments

C4-R Smoker Classification Questionnaire (revised), validated by Londoño et al. (2017), is the revised version of the C4 Smoker Classification Questionnaire created by Londoño et al. (2011) that measures the level of cigarette consumption and allows for classifying smokers as light, moderate risk, heavy and dependent. This instrument was subjected to a validation process and obtained an alpha of 0.90 in a population aged 18 and 35 (Londoño et al., 2011). The questionnaire items assess aspects such as the report of the symptoms that denote impact on health, the intensity of use of the substance such as frequency and depth of inhalation, and nicotine dependence signs.

Electrophysiological record of the startle reflex. The modulation of the defensive startle reflex was recorded, and this provided information on the motivational system activated in smokers by cues associated with cigarette smoking. The study was conducted by showing affective images selected from the International Affective Picture

System [IAPS] (Lang et al., 2008) taking into account normative Colombian values (Gantiva et al., 2011), and tobacco-related pictures (social celebrations, leisure time, cigarettes and packages) with appetitive valence and high arousal (Gantiva et al., 2012).

The defensive reflex modulation was used as the startle reflex with a sound stimulus (white noise of 50ms duration, 105EdB and instant rise time) to evaluate the affective valence produced by cigarette-related cues (Blumenthal et al., 2005).

Equipment and psychophysiological response measurements. For the visual and auditory cues, the E-Prime version 2.0 software was used (Psychology Software Tools, Pennsylvania, USA). The PowerLab 26T (ADInstruments) and LabChart software (v7.3, ADInstruments, Australia) were used to record the electromyographic activity, galvanic skin response, and heart rate. The different results were recorded with a sampling rate of 1.000 Hz and a bandpass filter between 5Hz and 500Hz. The transformation of the physiological data was done with MatLab 2012b software.

Procedure

Once the C4-R was applied and the participants classified with the SCS, the orbicular muscle's electromyography (EMG) was recorded during the startle reflex. In contrast, participants observed four categories of images (appetitive, neutral, aversive, and tobacco-related). This was carried out to observe the startle reflex modulation resulting from the decrease in the startle reflex amplitude with appetitive images and its boost with aversive images; both considered objective ways of measuring the motivational system activated by the image (appetitive or defensive).

The experiment showed 12 images in each category (48 images total) with 6 seconds per image. In each category, 7 images were accompanied by a white noise of 50ms duration, 90dB, and instant rise time to generate the startle reflex between 4,000ms and 5,500ms to measure

the startle reflex affective modulation. Of the 48 trials in the experiment, 28 of them had startle reflex.

The interval time between cues (ITI) was 10 to 14 seconds. In 4 ITIs, startle sound was applied to prevent the prediction phenomenon. 4 orders of presentation of the cues were organized to avoid the habituation factor. Each order was presented in a counterbalanced way among the participants.

The experiment was programmed with the E-Prime 2.0 software. The EMG recording was done with the PowerLab 26T at a sampling rate of 1,000Hz and a bandpass filter at 10Hz to 500Hz, with a softening every 20ms. The startle reflex's amplitude was calculated by identifying the response's peak in a time window between 20ms and 150ms after the startling sound. The EMG activity average in the 50ms before the stimulus was subtracted from this value. The results were converted to T scores for processing in the Matlab software program. The psychophysiological recordings were analyzed using mean comparative statistics using the structural equation models and size analysis of the effect to assess the influence of the factors. All analyzes were performed using SPSS 20.0 software for Windows, specifically the AMOS application.

Ethical considerations. The institutional ethics committee previously approved the study to ensure compliance with ethical research standards involving humans. It was determined that the procedure did not present any danger to the volunteers. Moreover, all participants signed an informed consent form as a requirement for taking part in the research.

Results

The startle reflex amplitude was 48.53 for appetitive images, 51.71ms for aversive images, 50.44ms for neutral images, and 49.29ms for those related to cigarettes (Table 2).

Table 2

Startle reflex amplitude in the various types of images

| Images | Minimum | Maximum | M | FROM | ED |
|------------|---------|---------|-------|-------|------|
| Appetitive | 42 | 55 | 48.53 | 2.806 | 2.81 |
| Neutral | 44 | 58 | 50.44 | 3.187 | 3.19 |
| Aversive | 44 | 61 | 51.71 | 3.401 | 3.40 |
| Tobacco | 41 | 56 | 49.29 | 3.591 | 3.59 |

ANOVA was processed to determine statistically significant differences between the groups of consumption level in psychophysiological aspects recorded at the moments: appetitive, neutral, aversive, and tobacco. The results indicated (Table 3).

Table 3

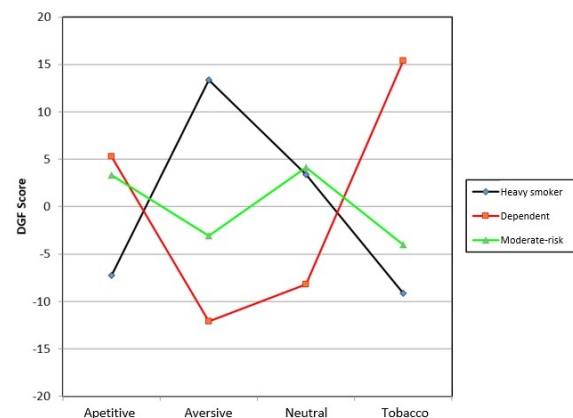
One-way ANOVA

| Variable | Sum of squares | df | Mean square between groups | Mean square within groups | F | p |
|------------|----------------|----|----------------------------|---------------------------|------|--------|
| Appetitive | 299.1 | 38 | 6.2 | 8.0 | 0.78 | 0.4659 |
| Neutral | 386.1 | 38 | 5.6 | 10.4 | 0.53 | 0.5881 |
| Aversive | 439.5 | 38 | 21.6 | 11.0 | 1.96 | 0.1553 |
| Tobacco | 489.9 | 38 | 21.3 | 12.4 | 1.71 | 0.1946 |

Comparing dependents with high tobacco consumption, it is observed that the greater differences are in aversive and tobacco stimulus. However, the dependent has the lower result in aversive and the highest one in tobacco. That indicates that it is possible that there was a differential perception of content due to the consumption level (Figure 1).

Figure 1.

Comparative analysis of tobacco consumption level and stimulus score.



Discussion and Conclusions

According to the startle reflex psychophysiological measurements, although there are no statistically significant differences in response to the tobacco-related images, there are differences between the dependent and high consumption groups. This means that the motivational priming, or emotional valence of the image, differentially modulates smokers in the smoking levels proposed in the Smoking Classification System C4-R. Previous research had already consistently linked motivational priming evaluated through the startle reflex records in different world populations, including Colombians (Gantiva et al., 2015; Grillon & Baas, 2003; Muñoz et al., 2013).

Consumers' habituation to visual stimuli related to the substance occurs due to the high exposure to social and environmental stimuli that present positive or negative cigarette consumption effects. It may explain the tendency to decrease the psychophysiological response emitted before images, directly and indirectly, related to the use of the substance since these are not always cognitively processed and initiate a neutral effect in all consumers, as shown by Teixeira do Carmo et al. (2005), Gantiva et al. (2016), Tonkin and Hawk (2020), and García-Gonzalez et al. (2020).

Conditions that undoubtedly could also be explained by memorizing the positive responses given due to the satisfaction of the desire to smoke and the pleasure experienced before using the substance. A learned psychophysiological response to the use of the substance can help explain the lack of identification of differences in this type of response between the different levels of consumption, a process previously described by the National Institute on Drug Abuse (NIDA) (2020), Lerman et al. (2020) and Wiggert et al. (2016). For this reason, it is necessary to develop new research in which reactions to different stimuli associated with liking and disliking, among other psychophysiological responses, are compared between smokers and non-smokers.

This helps to understand why, despite the appearance of negative effects, such as the

decrease in lung capacity reflected in the increase in tiredness and fatigue reported by smokers, in addition to the lack of taste discrimination, smokers tend to focus their attention on the physiological sensations of pleasure that appear immediately after using cigarettes. Conditions identified in previous studies by Ersche et al. (2020), Castellanos and Londoño (2019), and Perkins et al. (2017).

In summary, the proposed SCS can be considered that different levels of tobacco use have different psychophysiological responses, and this confirms this classification. However, it is necessary to carry out studies to confirm these findings.

Limitations and future directions

This study's limitations included low availability of heavy smokers and dependents to participate and that the study was done mainly on women, which did not allow making gender comparisons. There remain new questions about the real prevalence of the different types of consumption, for example, develop new research about the different psychophysiological reactions in smokers and non-smokers.

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Notas

- * Research article.