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The influence of tobacco exposure in color vision

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ABSTRACT

Cigarette has about four thousand types of substances and its consumption is a risk factor for a variety of diseases, including neuro-ophthalmic disorders. This is a literature survey about the influence of smoking on color vision. Review of literature based in the Google Scholar research platforms, Scielo, Science Direct and the Bank of Dissertations and Theses of CAPES. Smoking articles, smoking, smoking and color vision and color vision in articles titles were adopted for inclusion criteria. Thus, 31 of which were sealed. In addition to cognitive changes, chronic use of tobacco can cause damage to retinal cells, impairing color vision, changes in tear protein patterns, adverse effects on the precorneal tear film and ocular surface. Metabolism is indirectly affected by means of the reduction of plasma levels of antioxidants and increasing the production of free radicals that impair eye health and blood flow in the ocular choroid. The chronic consumption of cigarettes causes changes in color vision / discrimination and such analysis alerts the harmful effects caused by the substances that compose it. In addition, psychophysical vision examination can be used as a screening test for intoxication processes that may be occurring in the subject.

Keywords: Smokers; Smoking and vision; Smoking and color vision; Color vision

1 INTRODUCTION

The World Health Organization estimates that about 6 million people die each year as a result of tobacco, yet 5 million are active consumers and more than 600,000 are passive smokers. This makes tobacco one of the biggest threats to public health (WHO, 2015).

The cigarette has about four thousand types of substances (ROSE *et al*., 2014), among them is benzene, polonium 210, hydrogen cyanide, formaldehyde, xylene, dichloro-diphenyl-trichloromethane (DDT), phosphorus P4 and P6, phenol and nicotine (WHO, 2015). Heavy metals such as cadmium, lead and copper, which

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accumulate in the crystalline lens and exert greater toxicity are also present in cigarettes (SOOD *et al*., 2003).

Using imaging studies, studies show that when comparing smokers with non-smokers, the former presented lower cortical volume in bilateral prefrontal regions, occipital lobe and temporal lobe (WANG *et al*., 2017). Neuronal changes resulting from chronic smoking may also occur in anatomically distinct brain regions (FERNANDES; ALMEIDA, SANTOS, 2017).

Nicotine, the main ingredient of tobacco, when absorbed chronically, causes cognitive damages interfering in decision-making, reward, attention, perception, motor capacity, learning and memory, increased desire to smoke (WANG *et al*., 2012). And even with the deprivation of nicotine in chronic users, after long period of cessation, one can still observe damages of these cognitive and attentional abilities (FERNANDES; ALMEIDA, SANTOS, 2017; GORIOUNOVA; MANSVELDER, 2012).

The cigarette consumption is also associated with ophthalmic changes such as age-related macular degeneration, cataracts, shortening of the time for tear-film breakage (MATSUMOTO *et al*., 2008), visual disturbance with symptoms such as itching, burning in the eyes and dryness suggestive of dry eye syndrome (THOMAS *et al*., 2012).

It is known that color vision is a condition of perception that corresponds to a response produced by the brain to the light uptake of the environment by retinal photoreceptors (LIMA *et al*., 2011), which are responsible for the detection of light in a highly illuminated environment (cones). Cigarette consumption is also related to the decrease in color vision involving both the green-red and the blue-yellow axis (ARDA *et al*., 2015; BIMLER; KIRKLAND, 2004).

Having regard to the various substances proven to be toxic to the body and the sensitivity of vision to exposure to various chemicals in that composition, many of the changes in visual functions resulting from intoxication may occur even before other more serious impairment in the body and subclinically, the examination of vision can be used as a sign that the intoxication process is taking place (LOIS *et al*., 2008).

Several studies have investigated the effects of chronic tobacco use on cognitive function by evaluating the performance of individuals, but few studies have been conducted on the chronic use of tobacco in color vision, particularly in relation to the mechanism of action of tobacco on color discrimination.

This study made a literature's survey on the influence of smoking on color vision.

2 MATERIALS AND METHODS

This is a literature review on the relationship between smoking and color vision. The databases were used in the period from October 2018 to March 2019 to search the following platforms: Google Academic, Scielo, Science Direct and the CAPES dissertations and theses Bank. The following descriptions are given in the title of the paper (in Portuguese and English). Smoking articles, smoking, smoking and color vision and color vision in articles titles were adopted for inclusion criteria. Thus, 89 articles were found, 31 of which were sealed.

3 RESULTS

In this section we will present a summary of the main findings described in the works reviewed with the aim of presenting the reader with an overview of smoking and its effects on health, with emphasis on the visual system and, in particular, the color vision.

According to World Health Organization (WHO), smoking has become a serious global public health problem. Of the nearly 1.3 billion smokers in the world, more than 6 million die each year from exposure to tobacco (WANG, *et al*., 2012). WHO believes that by 2030 cigarettes can kill about 9 million people a year worldwide (FERNANDES; ALMEIDA; SANTOS, 2017; YANBAEVA, *et al*., 2007).

In Brazil, 23 people die every hour (CARGNIN *et al*., 2015) from smoking and affects 17.2% of the population above 15 years (AZEVEDO; FERNANDES, 2011). In 2013,

the National Health Survey (PNS) evaluated individuals aged 18 years or more from all over Brazil and found a higher prevalence in the South region (IBGE, 2014) and in the rural area of Brazil, compared to the urban (XAVIER; DEL-PONTE; SANTOS, 2018).

In more developed or developing countries, a significant reduction in the prevalence of smoking has been achieved; however, in the world as a whole, smoking is still increasing, particularly in low-income countries and in poorer populations with lower education (CARGNIN *et al*., 2015).

The color perception consists of stimuli that vary over space (spatial contrast), time (temporal contrast) or direction of motion, as well as luminance (acromatic) and chromaticity (saturation and color of the hue) (FERNANDES; ALMEIDA; SANTOS, 2017).

The photoreceptors, in particular the cones, play the most important role in the physiology of color vision, because they are located in the inner layers of the retina and receive light that surpasses the various retinal layers, originating the electrical impulse. The signals after crossing the photoreceptors are modified by post-receiverialprocesses to reach the last level, the layer of the ganglionic cells and finally, the information travels through the optic nerve, continuing to the Central Nervous System (CNS) (MOTA, 2011; MELAMUD; HAGSTROM; TRABOULSI, 2004).

In addition to nicotine, other compounds present in cigarettes such as tar, nitrosamines, hydrocarbons, hydrogen cyanide, formaldehyde and carbon monoxide (FERNANDES; ALMEIDA; SANTOS, 2017; MASMALI *et al*., 2016) are also toxic resulting in various adverse health effects and cause pathological disorders in different organs, including the eye. It is believed that these toxic and oxidative effects play an important role in eye changes and are then considered one of the risk factors for many eye disorders (FRANZ; SABUNCUO; PFEIFFER, 2002).

4 DISCUSSION

The toxins in the cigarette cause eye changes by decreasing blood flow or assisting in the formation of clots within the ocular capillaries, thus eliminating the nutrients essential for eye health (MASMALI *et al*., 2016; THOMAS *et al*., 2012;

TIMOTHY; NNELI, 2007). These toxins and irritants present in cigarette smoke cause a reaction of the conjunctiva and eye redness (THOMAS *et al*., 2012).

It is known that smoking increases the production of free radicals (ROSE *et al*., 2014) that damage eye health (THOMAS *et al*., 2012), affects the flow of blood in the ocular choroid, as well as ischemia, hypoxia and micro infarction increasing susceptibility to degeneration (SOOD *et al*., 2003).

Metabolism is indirectly affected by chronic cigarette use by decreasing plasma levels of antioxidants (SHAZLY *et al*., 2012; SOOD *et al*., 2003).

According to studies, it has been suggested that the mechanism linked to these changes is the reduction of carotenoids, lutein and zeaxanthin that are antioxidants since smoking is responsible for the decrease of plasma antioxidants, responsible for protecting cells from the retina, exposing them to free radicals (SOOD *et al*., 2003). These mechanisms can affect cone-like receptor cells, which have a high density in fovea and can lead to color vision disorders (ARDA *et al*., 2015).

Some authors suggest that chronic cigarette use is related to toxic neuropathy linked to smoking that affects color vision especially the green-red axis (KRASTEL; MORELAND, 1991). It is also suggested that carbon monoxide in cigarette consumption may be the cause of red-green dyschromatopsia (VOKE; FLETCHER, 1985). Thus, cigarette consumption is also related to the decrease in colour vision involving both the green-red axis and the blue-yellow axis (ARDA *et al*., 2015; BIMLER; KIRKLAND, 2004).

Cone saturation, amplification of signals reaching the visual cortex or nicotine action in the parvocellular pathway results in alteration in color discrimination (FERNANDES; ALMEIDA; SANTOS, 2017).

The lens and retina contain several potent antioxidants that include some enzymes, glutathione, vitamin C, E and carotenoids (carotene, lutein and zeaxanthin). Antioxidant enzymes are the first-line defense system supported by antioxidant vitamins. Lutein and zeaxanthinare the main carotenoids of the lens and are found only in the retina at high macula concentrations (FLETCHER, 2010).

Nicotine influences mood, cognition and body function by activating nicotinic acetylcholine receptors (nAChR) located in neurons in the brain (FERNANDES *et al*. 2018; D'SOUZA; MARKOU, 2011).

There are nAChRs in functional visual processing units such as retinal cells, lateral geniculate nucleus and primary visual cortex. The imbalance in the neurotransmission of acetylcholine, dopamine and glutamate and deficiencies in the functioning or conformation of the receptors may modify visual processing. It is suggested that smoking affects visual processing because of nAChRs present in bipolar, amacrine and ganglionic cells (FERNANDES; ALMEIDA; SANTOS, 2017).

A long-term study with smokers demonstrated that there was a change in contrast sensitivity and the ability to discriminate between non-smoking individuals,thus suggesting greater attention to the evil effects of cigarettes on the visual system (DICKERSON *et al*., 2013; FERNANDES *et al*., 2018).

5 CONCLUSION

In view of the results of the studies reported above, it can be concluded that the chronic use of cigarettes causes cognitive prejudice in terms of color vision/discrimination and such an analysis alerts on the harms caused by the different chemical substances which compose the cigarette. Furthermore, it indicates that visual system investigation can be used as a screening test for an intoxication process that may be occurring in the individual. However, further studies are needed to better assess the impact of these changes on health and the underlying mechanisms.

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