About Red Light/Green Light and Also Blue Light: Wavelength Specific Findings With Acute Marijuana Use

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While the popular television show of Squid Games made the horror and death of the game Red Light/Green Light seem real, we all knew the risk of any harm never really existed [1]. The same cannot be said of the potential harm and fatalities from not obeying Red Lights/Green Lights on real roads. And the harm is greater in cities now having legal adult use of marijuana. The rate of running red lights went up 18% in the city of Denver, Colorado USA, when legal adult use marijuana sales began [2]. The most recent records from 2022 show that in the USA there were 1,149 fatalities attributed to the running of red traffic lights [3].

A potential explanation for these increasing fatalities at red lights are the dead spots, gaps in vision that occur with acute use of inhaled marijuana. Marijuana causes dysfunction of those visual pathways that rely on accurate input from dopaminergic receptors. When these are disrupted such as with the inhalation of marijuana, these pathways are dysfunctional. The pathways impacted are not the parvocellular visual paths processing colour and precise vision such as acuity, but the magnocellular pathways processing peripheral vision, contrast, motions, depth, and other non-acuity non-colour functions. That these pathways are significantly impaired with inhaled marijuana was reported in 2018 [4]. The dysfunction reported demonstrates that a marijuana user would potentially have blind spots large enough to obscure the overhead Red Light/Green Light traffic signals. Unlike for alcohol, the amount of marijuana in blood or saliva does not linearly relate to actual impairment. So objective tests of functions critical for safe driving are needed.

The data from the initial study reported research is superimposed on the windshield of a car in motion in the image below. A driver having recently used marijuana potentially cannot see the traffic signal, let alone determine if it is Red Light/Green Light. The impact of marijuana within the eye's retina is complex because every layer of the retina have cannabinoid/marijuana receptors [5, 6] and depending on which layer can be excitatory or inhibitory. Recent inhaled use of marijuana takes the dopamine out of the retina [7, 8] and reductions in dopamine result in visual impairment due to inhibition. This impairment can be measured using tests of the magnocellular pathway. One such test is the Frequency Doubling Technology (FDT) [9] visual field which is commonly used to measure glaucoma. But the technology can detect dopamine depletion [10]. The science behind FDT is complex, but the test is simple. The instrument displays small striped squares of a fixed temporal stripe flip but variable contrast. A person presses a button whenever they see stripes. The original FDT technology was in a tabletop test, but now systems with the test in simple virtual goggles are available. IMMAD, Impairment Measurement Marijuana and Driving [11] has demonstrated efficacy of using visual reality goggles having the complex striped target for the

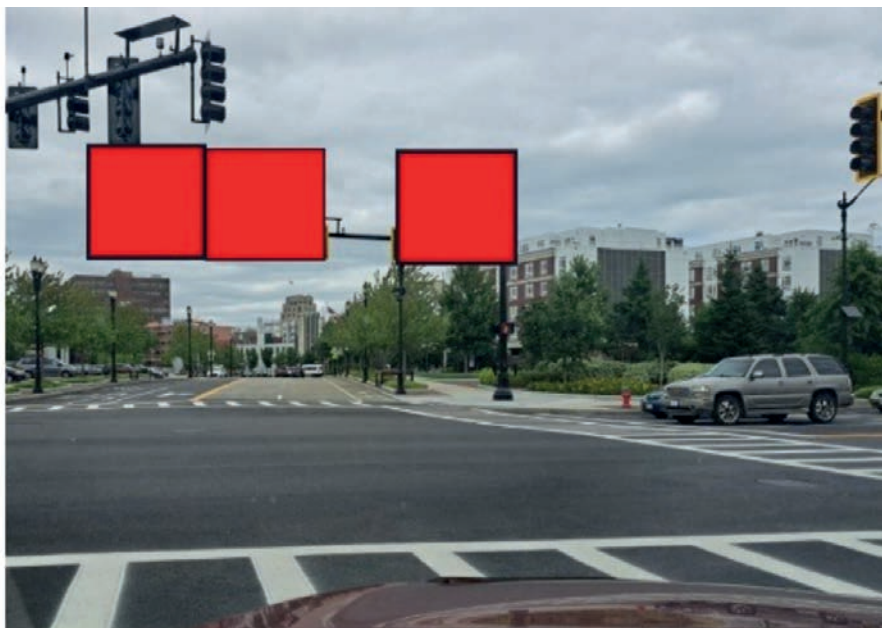

Figure 1: IMMAD identified significant visual field losses with inhaled marijuana use. These are demonstrated by the red squares displayed against the driver's side windshield.

Figure 2: Intern Dr Xueling Zou tests an opportunistically dosed research participant with IMMAD.

detection of marijuana depletion of the retina induced blind spots [12]. Pictured is a research participant after having self dosed under an IRB approved opportunistic dosing protocol. Part of the research involved real car, closed road driving. This was funded by the National Institute of Justice [13]. This research discussed was supported by Award No. 15PNIJ-22-GG-04417-RESS awarded by the National Institute of Justice, Office of Justice Programs, US Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this program are those of the author and do not necessarily reflect those of the Department of Justice.

The data on impairment obtained from the IMMAD technology after marijuana use shows a relationship to the retinal location of a subclasses of retinal ganglion cells, the melanopsin-expressing intrinsically photosensitive retinal ganglion cells (ipRGC) [14]. The function of these cells include contrast sensitivity perception, depth perception, and motion perception. Other research has found decreases in contrast sensitivity perception with acute marijuana use [15].

The ipRGC are responsible for what is referred to as the post illumination pupil response (PIPR). PIPR is the sustained constriction of the pupil when pupil responses are considered normal. Part of a drug evaluation performed by law enforcement roadside is using a light to determine pupil response and when marijuana is suspected to be causing impairment to drive they are looking for a specific pupil re dilation with continued illumination of the pupil [16]. The dysfunction in sustained pupil constriction is referred to as rebound dilation. The pupil initially constricts with direct illumination but then has a partial dilation with continued direct illumination with marijuana use. The ipRGC are temporarily inhibited with acute marijuana use and the failure to respond are the contributing factors in the observation of rebound dilation [14].

We discussed Red Light/Green Light and now we are going to discuss Blue Light. Blue light is the primary driver of both direct and consensual PIPR response under normal circumstances, absent the use of marijuana [17-19]. To observe the marijuana induced rebound dilation the light source, penlight needs to have blue wavelengths. Because the observation of the cannabis induced dysfunction of rebound dilation is chromatically driven. It is observed with illumination sources having blue in the wavelength spectrum.

Red Light/Green Light? Red wavelengths will illicit the response, but lesser so than blue light. The response to red is because in the absence of any substance such as marijuana, a normal pupil response, there is a consensual response to red light [19]. The distribution of those cells responsive to red light is in the nasal retina. Nasal retinal cells cross over to the opposite side of the brain and thus consensual but not direct responses. Green light does not illicit any marijuana related rebound dilation response as green light drives primarily cone related functions, not ipRGC.

With the advancement of technology such as IMMAD, as well as discovery of the intrinsically photosensitive retinal ganglion cells (ipRGC)[19-23], there has been improved understanding of marijuana induced dysfunctions in the visual system. Techniques to measure the dysfunctions related to visual perception in the magnocellular pathways involving contrast, peripheral vision, depth and motion and pupil responses, helps us better identify those drivers impaired by marijuana and remove these deadly drivers from our highways and roads. IMMAD is an effective technology to determine the impairment of functions critical for safe driving such as motion, depth, and contrast.

The inability to see Red Light/Green Lights after inhaled marijuana consumption can result in more deaths on our roads. Pertaining to the use of marijuana and driving, it is not a game, there are real life consequences with potentially fatal outcomes.

Figure 3: The marijuana dysfunction in post illumination pupil response is elicited with red and blue wavelength light sources. Green and white light sources do not elicit the dysfunction.

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