

Infrared Pupillometry and Eye-tracking as Next-generation Non-Intrusive Means to Identify Subjects Under Influence of Psychoactive Drug and Vision-related Harms

Executive Summary

Pupillary light reflex (PLR) is known to be affected by the use of psychoactive substances (PAS) through the autonomic nervous system. Stimulants such as crystal methamphetamine (Ice), ketamine, and cocaine can cause pupil dilatation (mydriasis) while narcotics including heroin can cause pupil constriction (miosis).

The impairment of PLR by PAS can be quantified by infrared pupillometry (iP) as the temporal sequence of changes in the pupil size upon light stimulus.

We modified the Virtual Reality (VR) headset and installed the iP as well as the Doolon F1® eye-tracking add-on cameras, which provides 120Hz sampling rate measurements on both eyes. Initial pupil size, response time, 2/3 constriction time, 1/3 re-dilatation time and slow-phase dilatation velocity using light of low (PLR 64) (RGB 64, 64, 64), medium (PLR 128) (RGB 128, 128, 128) and high intensity (PLR 64) (RGB 255, 255, 255) that based on initial pupil diameter (PLR+) will be recorded.

The preliminary results we collected has clearly shown some significant differences in both iP and eye-tracking (ET) data between healthy and Psychoactive Substance Abusers (PSA) group, especially for the subjects with history of taking cannabis. The differences of Normal Pupillary response (NPR) and Pupillary unrest (PU) are as follows:

Normal pupillary response (NPR)

An NPR graph shows the following characteristics and criteria:

1. Steady pupil constriction and re-dilatation at the end of the light stage
2. Smooth pupil dilatation during dark stage
3. Shorter time to recover to baseline of pupil size after light stage

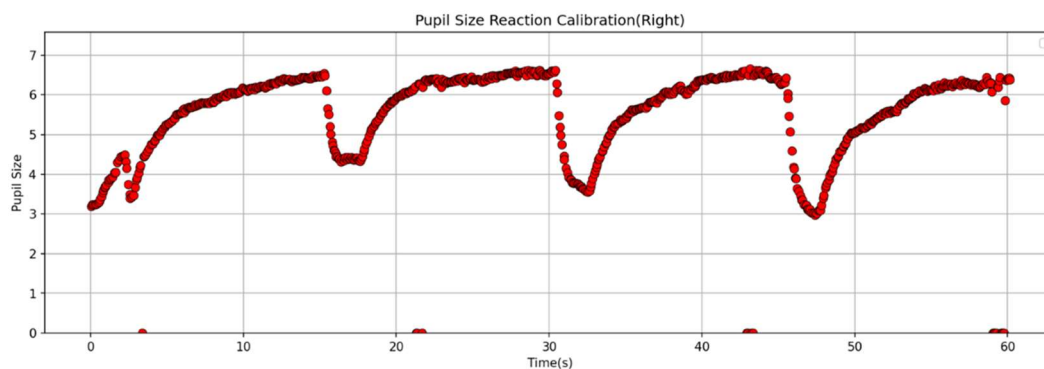
Pupillary unrest (PU)

PU shows the following characteristics and criteria:

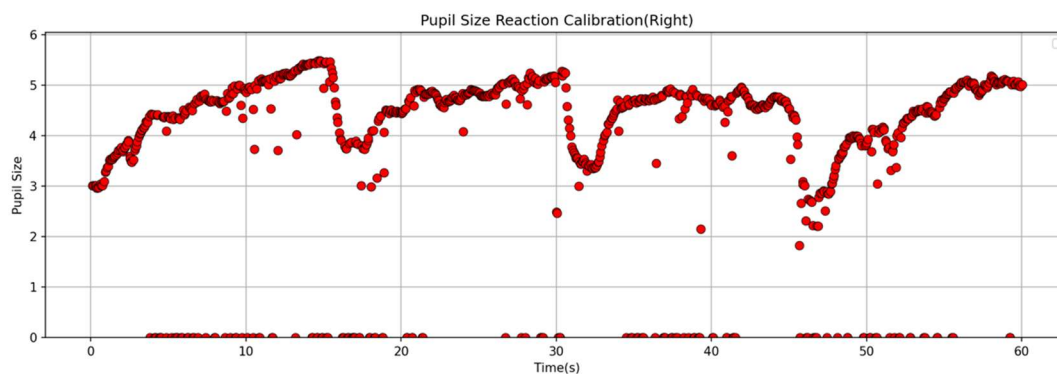
1. Fluctuating pupil constriction and dilatation
2. Unrest pupil dilatation during dark stage
3. Longer time to recover to baseline pupil size after light stage
4. Latency of pupil constriction upon light stimulation

Figure 1: The difference between normal pupillary response (NPR) and Pupillary unrest (PU)

(a) Normal pupillary response (NPR)



(b) Pupillary unrest (PU)



It is easy to recognize PU in PSA (95.2% and 93.3% in both visits) by using our infrared pupillometry and eye-tracking (iP&ET) device. Also, iP&ET test has longer detection windows,

as most of the cases we discussed above had quitted drugs for several months or even longer time, but the abnormal pupillometry results can still be detected.

Group	Normal pupillary response (N, %)	Pupillary unrest (N, %)
Healthy		
Total (N=500)	482 (96.4%)	18 (3.6%)
PSA		
1st visit (N=125)	6 (4.8%)	119 (95.2%)
2nd visit (N=106)	7 (6.6%)	99 (93.3%)

Our VR iP&ET setup has a lot of advantages, including low-cost and high portability which can unleash immense potential and can be deployed in various locations. Also, across the study, we received lots of positive feedbacks from the users including the public, PSA, and social workers in the community centres. Some of the rehabilitee centres also show interests in future cooperation towards our non-intrusive VR iP&ET device.

Our iP&ET device has a huge potential on first-line screening in community, which can be deployed in schools and community centres etc. We are excited to work and improve our VR iP&ET setups in the coming future and focus on fighting against cannabis, the new trendy drug among our society.