Investigating Evoked Pupillary Responses to Targets Presented in Virtual Reality

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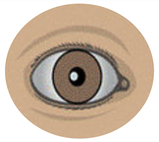
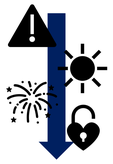
Background

A pupil dilation is the widening of the pupil and can have several reasons such as an involuntary reflex reaction to light exposure, or it can be an indicator of arousal and attention.

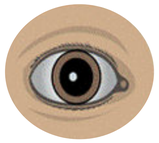
In this experiment, we wanted to learn about how our pupil size changes depending on what we see. If we see an object of interest, then would there be a greater and/or faster pupil dilation? Does it take longer for our pupils to dilate when we are moving our heads to look at the object rather than just moving our eyes to look at it?



Undilated Pupil



Several Causes



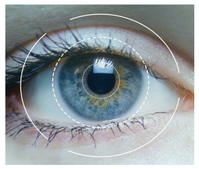
Dilated Pupil

Methods

We used Virtual Reality to simulate a 3D environment for the experiment. The subjects drove down a road with white billboards on the left and right in which would show an image of the chosen four categories-- a camera, ship, laptop, or piano-- on one of the billboards randomly. Among these four categories, the camera was the target category. Subjects were instructed to count the number of targets (cameras) that appeared in each run and report it to the experimenter at the end of the run.

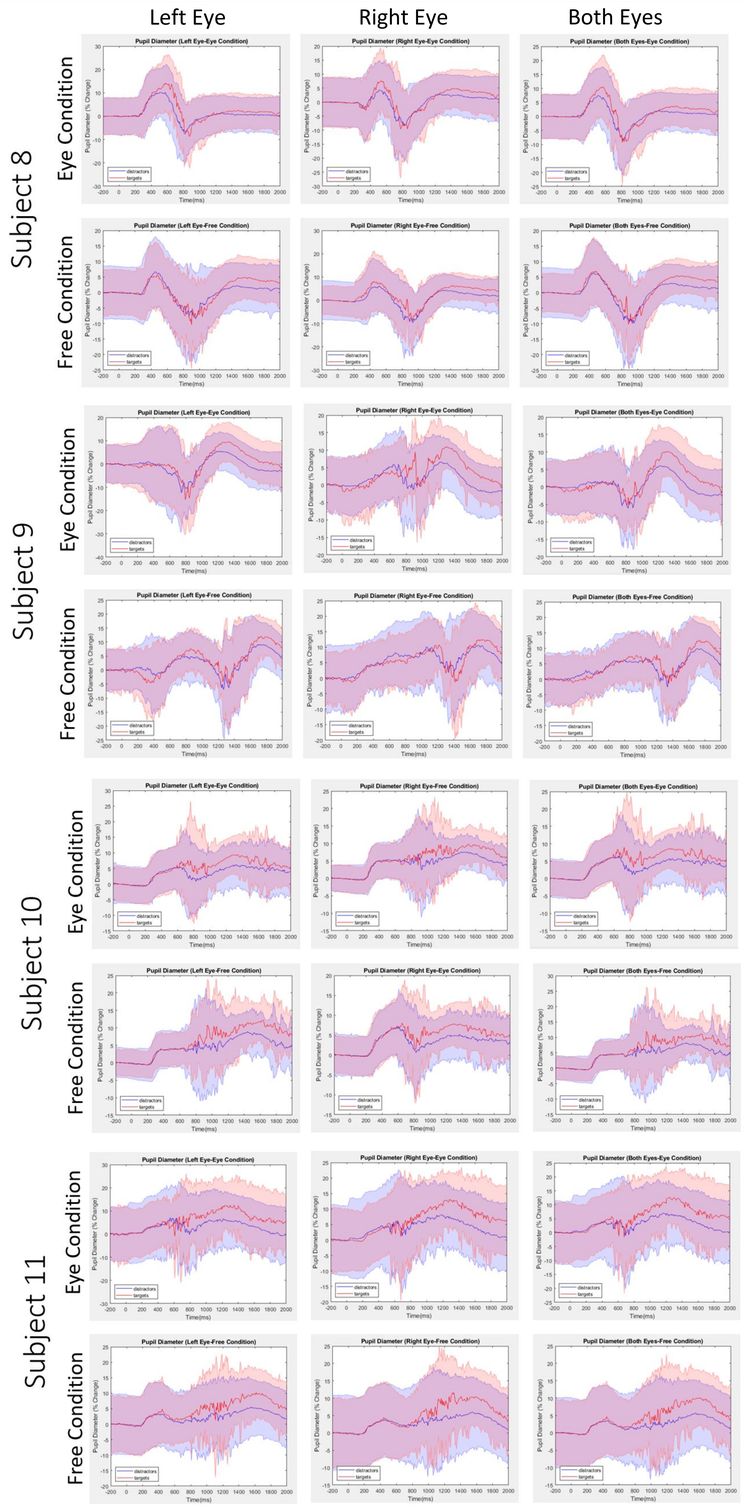
Subjects performed two different conditions with this task, the “eye” condition, where the subjects had to keep their heads still and only moving their eyes to look at the billboard; meanwhile, in the “free” condition, the subjects had to move their heads towards the billboard to see the image.

We used an eye tracker to collect our data. Using MATLAB, we calculated the percent of change in pupil diameter 0.2 seconds before and 2 seconds after an image showed up. We averaged the data every time the image was a camera and plotted it as the target category (red line). The same was done for the other three images and plotted as the distractor category (blue line). We also found the standard deviation of the targets and distractors (shaded area around the line).



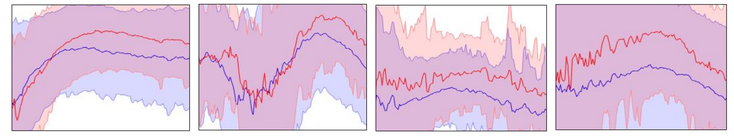
MATLAB

Results



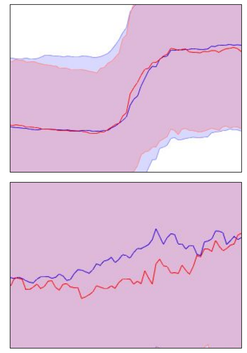
Discussion

Based on the graphs, we were not able to conclude a specific pattern in the change of the pupil diameter. However, we found that the pupil tends to stay more dilated after seeing a target than after seeing a distractor. The target (red) is above the distractors (blue) after around 1 second.



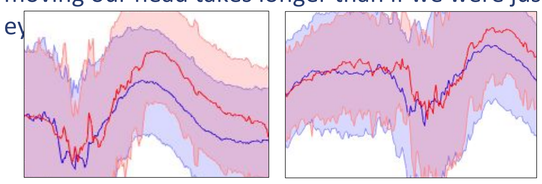
Subjects 8-11 (from left to right) in the free condition for both eyes, from 1 second to 2 seconds.

Each subject had a unique pattern in diameter change. For subjects 8 and 10, there is a sharp increase in change at 0.2 seconds for both conditions. For subject 11, there is a sharp increase in the free condition and a gradual increase in the eye condition. Meanwhile, subject 9 shows a gradual increase in both cases. We can infer that it takes around 0.2 seconds to fixate our eyes from the center of the road to the image. Pupils increase after noticing that an image has appeared on the billboards.



Subject 10 (top) and subject 9 in the free condition for both eyes between 0 to 0.5 seconds

In addition, most ‘Both Eyes’ graphs show a slight shift to the right in the free condition. For example, in the eye condition, subject 9 shows a decrease at 0.6 seconds and then it begins to increase at around 1 second. In the free condition, this pattern happens at 1.1 seconds and 1.5 seconds respectively. This is justified because moving our head takes longer than if we were just moving our ey



Subject 9’s eye condition (left) and free condition between 0.5 seconds to 2 seconds in the range of -10% to +15%

Although each subject had a unique pattern of change, we noticed that the pupil size is 1-5% greater after seeing a target than after seeing a distractor, and dilation occurs later in the free condition compared to the eye condition.

Acknowledgements

Thanks to Pawan Lapborisuth for his mentorship; Dr. Paul Sajda for providing the opportunity to participate in his lab; and Mike Carapezza for his advice and support throughout the internship.

LIINC Laboratory for Intelligent Imaging and Neural Computing

The Pinkerton Foundation