Investigation of a phase-locked mechanism: saccades to non-flickering targets on a bright pulsating background

IFADo

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Introduction

Pulsating illumination of VDU is usually regarded as an important source of visual discomfort or fatigue especially during reading. To understand the causes of these effects, previous studies investigated saccades to stimuli that are presented intermittently on cathode ray tubes at refresh rates of 50 - 125 Hz. Results showed that flicker seems to affect saccadic control both on latencies, saccade extent and velocities. Several explanations have been also mentioned stipulating either a direct effect on saccadic computation during latencies (Kennedy, Brysbaert & Murray, 1998; Baccino & Jaschinski, 1999) or during the saccade itself (Baccino, 1999). Moreover, the lack of any DC control condition in these studies does not allow to disentangle between these interpretations. To extend these researches we measured saccades executed from central fixation to eccentric (5 deg) targets (red points of laser light, unmodulated in time). These were presented on a bright background produced by a purpose-made fluorescent lamp that was able to produce either steady DC light, or short pulses of light, since the special fast phosphor had a 2 ms rise-time and a 1 ms fall-time. The moment in time when the saccades began and ended was detected on-line and triggered the lamp to switch between steady light and trains of Gaussian-like light pulses of 4 ms duration. So, we controlled very precisely the period when pulses occurred during the different components of an eye movement (fixation, latency, saccade). The objective was to test during which period flicker might have the largest effect on saccadic control.

Method

2 experiments have been done with exactly the same layout except for the 2nd experiment, an additive procedure including the signal from the vertical retrace into the data collection. This procedure had for purpose to test the effect of a possible phase-locked mechanism between flicker and saccade onset. 22 participants were used in both experiments and therefore the analysis were done on 44 subjects.

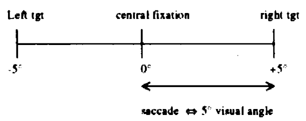


Figure 1

Participants focussed on a red central light. After 500 ms, this light was switched off. A new light switched on immediately (the target), either on the right or on the left of the central light with a visual angle of 5 degrees (see figure 1). The viewing distance was at 63 cm. We gave trains of pulses with 2 frequencies (50, 100 Hz) in 4 conditions of presentation: during fixation of the central launching position only (condition 8, 9), during the latency only (condition 4,5), during the fixation and during the latency (condition 6, 7) or during the flight of the saccade only (condition 2, 3). Before and after these trains of pulses, steady light of the same luminance of 67 cd/m2 was presented. Moreover, one condition was completely flicker-free (Condition 1). So, there was 2 (Direction : Left/Right) X 9 (Flicker Conditions – see table1) within-Subjects Factors .

	Fixation	Latency	Saccade	Moment of pulses
Condition 1	DC	DC	DC	None
Condition 2	DC	DC	50 Hz	Saccade
Condition 3	DC	DC	100 Hz	Saccade
Condition 4	DC	50 Hz	DC	Latency
Condition 5	DC	100 Hz	DC	Latency
Condition 6	50 Hz	50 Hz	DC	Latency + Fixation
Condition 7	100 Hz	100 Hz	DC	Latency + Fixation
Condition 8	50 Hz	DC	DC	Fixation
Condition 9	100 Hz	DC	DC	Fixation

Table 1

The figure 2 represents the 3 periods during which the pulses might occurred.

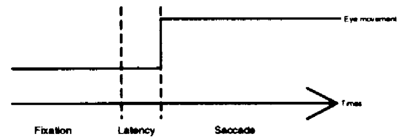


Figure 2

Results

Saccade Latency

There was a main flicker effect on saccade latencies with longer latencies at 50Hz comparing to 100Hz, [F(1,43)=18.43 p<.001] or DC condition, [F(1,43) = 27.40 p<.001]. (see figure 3).

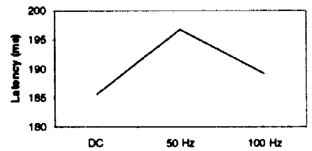


Figure 3

Exploring more in detail this effect, we can see that this large effect of 50Hz is mainly due when the pulses occurred ONLY during the latency,[F(8,344) = 13.06 p<.001] with an increasing latency in that case [Planned comparison : F(1,43) = 38.96 p<.001]. The figure 4 reveals the significant difference as function of the DC condition taken as control condition (no flicker at all).

With the purpose to show whether this effect might be dependent of potential individual differences in flicker perception, we have used a clustering analysis between subjects (taking the saccade latency as variable), and results show that the 50hz effect during the latency was independent of subject' performances (see figure 5). [High Latency Group: F(1,41)=24.56, p<.001); Medium Latency Group: F(1,41)=19.16, p<.001); Low Latency Group: F(1,41)=7.09, p<.05].

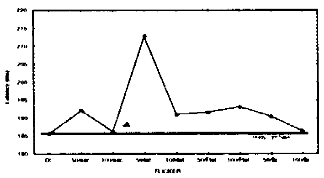


Figure 4

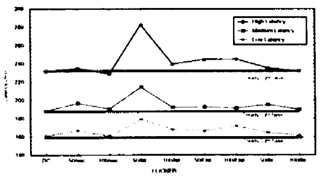
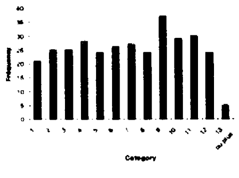


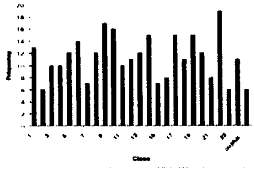
Figure 5

In order to see whether these delayed latencies at 50Hz might be due to a possible phase locked mechanism between the saccade onset and pulses, we have drawn the distribution of the last pulsation occurring before the saccade onset (temporal difference between the last pulsation

and the saccade onset) and compared to a theoretical distribution (random distribution). No evidence of synchronisation phenomena appeared (all X² ns).



Distribution of the last pulsation at 100 Hz



Distribution of the last pulsation at 50 Hz

Discussion

- First, this effect seems quite robust because we have replicated the same result with 2 independent groups.
- Secondly, recent modelling of saccade latencies (Clark, 1999) may explain our results. The main idea of the Clark' model is to show a functional link between spatial attention and saccadic latencies claiming that saccades are triggered when attention is engaged at a new target location. According to the model, the visual input information (the target) is processed by low level feature detectors creating a spatial saliency map. When the target feature value (on this saliency map) is high enough compared with the value of the current location, the attention is shifted to the new location and a saccade is triggered. We suggest that this process may be disturbed by the 50 Hz- pulsation during the latency.
- Thirdly, longer saccadic latencies at low flicker rate have also been shown by Kennedy et al. (1998) claiming for the adverse effect of that refresh rate on saccadic control. Our data extends that view revealing that the pulses at 50 Hz seem ONLY to be disrupting when they occur during the latency itself.

References

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