

# In the Drowsy State, Errors of Omission in a Visual Reaction-time Test Occur with Eyes Open or Closed

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## Introduction:

It cannot be assumed that failure to respond to a visual stimulus in a vigilance test [error of omission (EOO)] in the drowsy state is due simply to eyelid closure that blocks visual input.

In a previous pilot study, Johns (1) reported that 18 out of 23 EOOs in four sleep deprived drowsy subjects occurred when their eyes were open. Others have also reported some drowsy lapses with eyes open (2,3).

## Aim:

Our aim was to investigate in more detail the position of the eyelids during EOOs in a larger sample of drowsy subjects, classifying lapses according to whether the eyelids were open all of the time or some of the time, partially closed or fully closed.

## Methods:

Twenty seven consenting volunteers (M/F=15/12, ages 17-29yr) had their eye and eyelid movements recorded by infrared (IR) reflectance oculography (Optalert™) (Fig. 1) whilst they performed a 10-20 min visual reaction time test when alert and after being sleep deprived for 20-40 hr. The movements were confirmed by video camera.



Fig. 1. (left) The Optalert™ system of IR oculography. An LED housed in the bottom of spectacle frames emits pulses of IR light directed up at the eye. The light reflected back from the eye is recorded at 500 Hz by a phototransistor in the frame beside the LED. This gives a measure of the position of the eye and eyelids.

The Johns Test of Vigilance (JTV) was developed specifically for use with Optalert™. The stimulus, to which the subject responds by pushing a button as quickly as possible, is a change of shapes on a computer screen, from circles (Fig. 2a) to diamonds or squares (Fig. 2b). This lasts for 400 ms and is presented at random intervals of 5-15 sec.



Fig. 2a. JTV circles



Fig. 2b. JTV diamonds and squares

## Results:

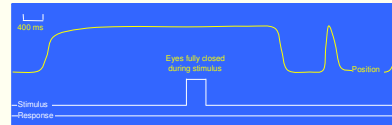


Fig. 3. In the drowsy state, some EOOs (no response) occurred when the eyelids were fully closed. There is a long eyelid closure here lasting 3.5 seconds.

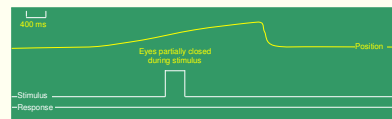


Fig. 4. In the drowsy state, some EOOs occurred during partial eyelid closure that would probably not have been sufficient to block vision when alert.

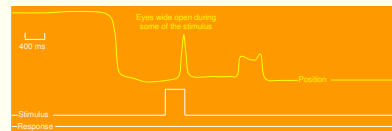


Fig. 5. In the drowsy state, some EOOs occurred with eyes wide open for at least 50 ms, but not all of the stimulus duration e.g. a blink during the stimulus, as here. When alert, a normal blink during the stimulus does not cause an EOO.

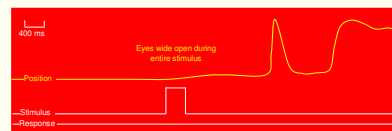


Fig. 6. In the drowsy state, some EOOs occurred with the eyes wide open, as shown above.

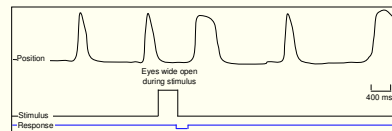


Fig. 7. In the drowsy state, subjects respond normally to a visual stimulus at times, as shown here.

There were 507 EOOs when sleep-deprived (9.6% of 5280 stimuli) but only 11 EOOs when alert (0.2% of 6971 stimuli). When drowsy, the eyes were fully closed throughout the stimulus for 46.2% of EOOs, partially closed throughout the stimulus for 27.8%, fully open for some of the stimulus for 11.2%, and fully open throughout the stimulus for 14.8%. A total of 26.0% of drowsy EOOs occurred with eyes wide open for long enough see the stimulus.

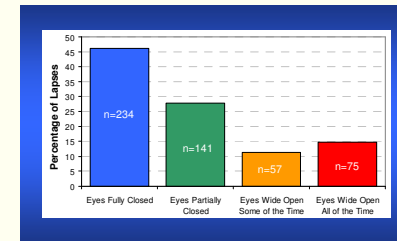


Fig. 8. Eyelid Status during 507 EOOs in 27 sleep deprived volunteers.

## Conclusions:

- The majority (53.8%) of all EOOs occurred without the eyelids being fully closed throughout the stimulus.
- 26% of EOOs in the drowsy state occur with eyes wide open all or some of the time, implying a failure of visual attention, mediated centrally.
- EOOs are much more common with sleep deprivation (9.6% vs 0.2% of stimuli) whether the eyes are open or closed at the time.
- Video camera systems cannot detect drowsiness that causes lapses in visual attention when the eyes are wide open.

## References

1. Johns MW. Eyelid closure, visual suppression and hypovigilance in the drowsy state: Lapses in performance with eyes open or closed *Sleep*, 2003; 26:A52.
2. Johnson, L. C., Freeman, C. R., Spinweber, C. L., & Gomez, S. A. Subjective and objective measures of sleepiness: effect of benzodiazepine and caffeine on their relationship. *Psychophysiology*, 1991; 28: 65-71.
3. Price, N. J., Malsin, G., Powell, J. W., Ecker, A. J., Szuba, M. P., Mallis, M. M., & Dinges, D. F. Unobtrusive detection of drowsiness-induced PVT lapses using infrared retinal reflectance of slow eyelid closures. *Sleep*, 2003; 26: A177.