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Effects of Lasers on Driving

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14. ABSTRACT

Thirty-eight human subjects participated in a study of the effectiveness of distracting lasers against the driver of a ground vehicle at checkpoints. The relative effectiveness of two different lasers with two different Nominal Ocular Hazard Distances (NOHD) were compared at two different levels of ambient light. Two experiments were conducted. The first experiment assessed relative perceptibility of the lasers. Subjects drove a card down a straight course and were instructed to stop as soon as they saw the green laser. Perceptibility was assessed by the time from the laser onset to cart braking. Results indicated that both lasers were perceivable under all tested conditions. The second experiment assessed the relative effectiveness of optical suppression. Subjects drove a straight course which dead ended, forcing the subject to choose to turn right or left, where one of the sides was blocked. Degree of optical suppression was assessed by the time the subject took to complete the driving course. Other measures of suppression included stopping in response to laser onset, avoidance behavior, and hitting barriers. The primary finding of the work was the importance of ambient light in determining effectiveness of green laser distractor in suppressing driver approach. While the laser lights can be seen at all times, optical suppressive effects are not apparent until after dusk.

15. SUBJECT TERMS

non-lethal weapons, effectiveness metrics, driving, lasers, green laser distractor, optical suppression, human behavior, checkpoint, ambient light, driver suppression, human experimentation

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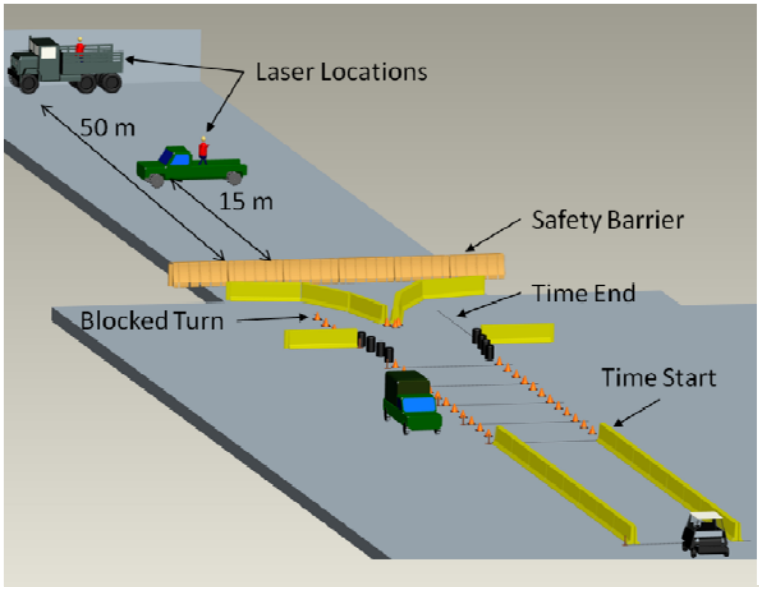
Introduction

- Previous Work
  - User's ability to keep laser on a target in an approaching vehicle (Riedener & Tran 2007)
  - Driver's reaction to lasers (and other signals) both naturally and with pre-instruction on the meaning of the signals (Mezzacappa 2008)
  - Suppressive effectiveness of green laser when navigating a chicane (Mezzacappa 2008)
- This work
  - Studied two paradigms related to proposed uses of lasers at checkpoints
  - Suppress/Stop
    - Ability of the laser to interfere with operation/navigation of the vehicle in spite of the driver's desire to continue
  - Hail/Warn
    - Addresses the driver's ability to perceive the signal and ability to willingly comply with a prior instruction

Method

- Protocol for use of human subjects was approved by the ARDEC Institutional Review Board.
- Informed consent was received from all subjects who were recruited from the general population (civilian) in northern New Jersey.



GBD-IIIC @ 50m (NOHD)
nLight @ 50m
nLight @ 15m (NOHD)

One turn blocked by cones. Cannot see which turn is blocked until close.

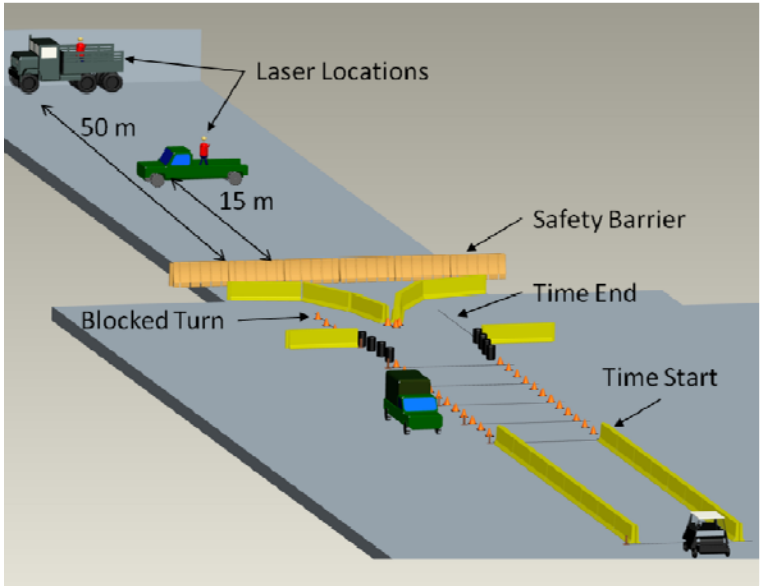
Day: 12 subj, age 19-52 (mean=33)
&
Dusk: 18 subj, age 19-52 (mean=34)

Malcolm Baldrige National Quality Award 2007 Award Recipient

Method: Suppress/Stop

- Drivers instructed to drive the track and choose the open turn, and to drive as fast as they felt comfortable.
- Laser triggered by sensor on ground.
- Driver would attempt to continue and choose correct turn.
- Between trials:
  - Driver asked about perception of laser.
  - Cones reset.
- Random order of:

Condition	Turn	Repeated
GBD-IIIC @ 50m (NOHD)	Left	4x
nLight @ 50m	Right	
nLight @ 15m (NOHD)		
None		



Method: Hail/Warn

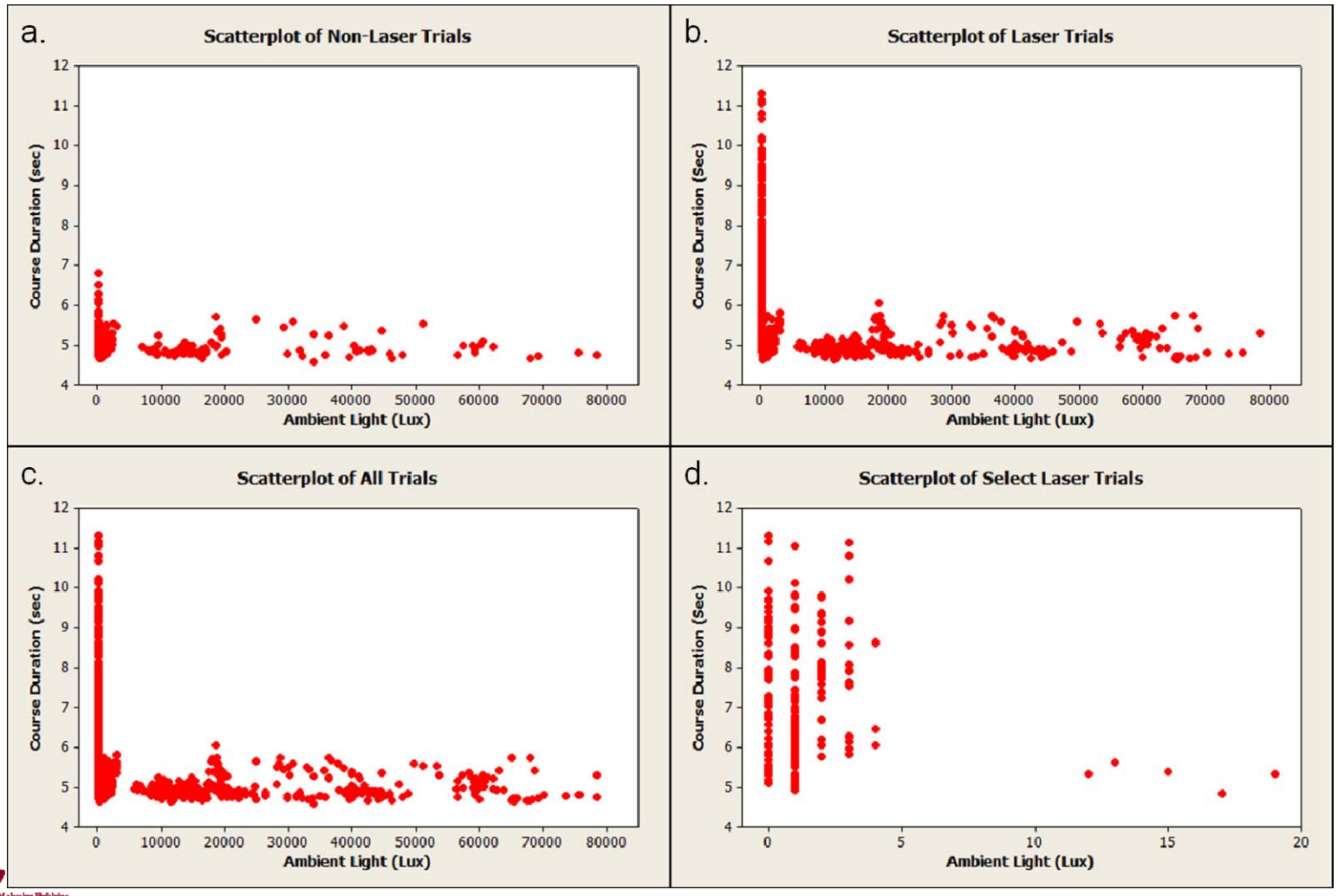
- Driver instructed to stop when they saw the green laser.
- Always exited using same turn.
- Do not stop if they do not see the laser.

- Ground sensor triggered laser trials.
- Laser came on after a random delay from sensor.
- Driver stops if they saw laser.
- Laser off and driver continues.
- Driver asked about perception of laser between trials.

- Random order of:

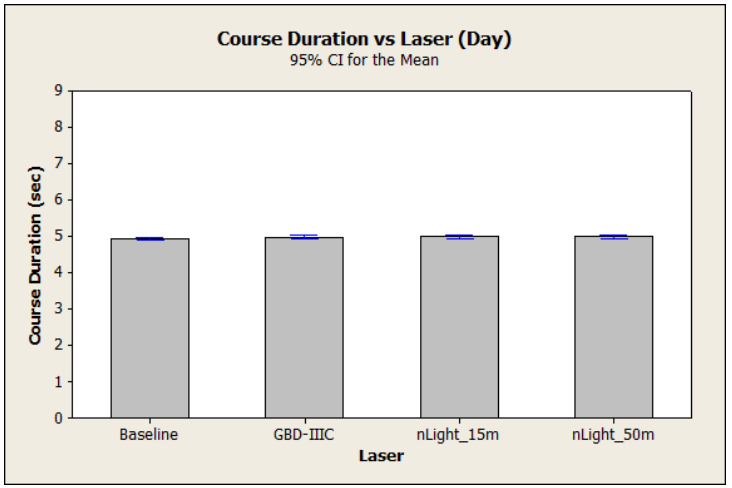
Condition	Repeated
GBD-IIIC @ 50m (NOHD)	8x
nLight @ 50m	
nLight @ 15m (NOHD)	
None	

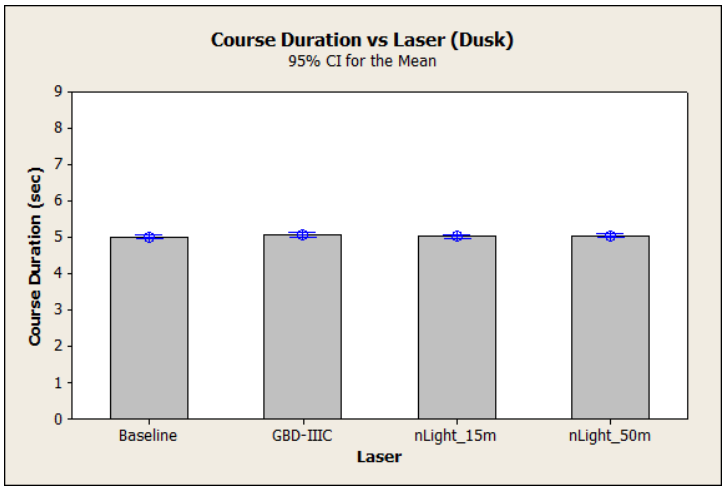
Results: Suppress/Stop



Results: Suppress/Stop

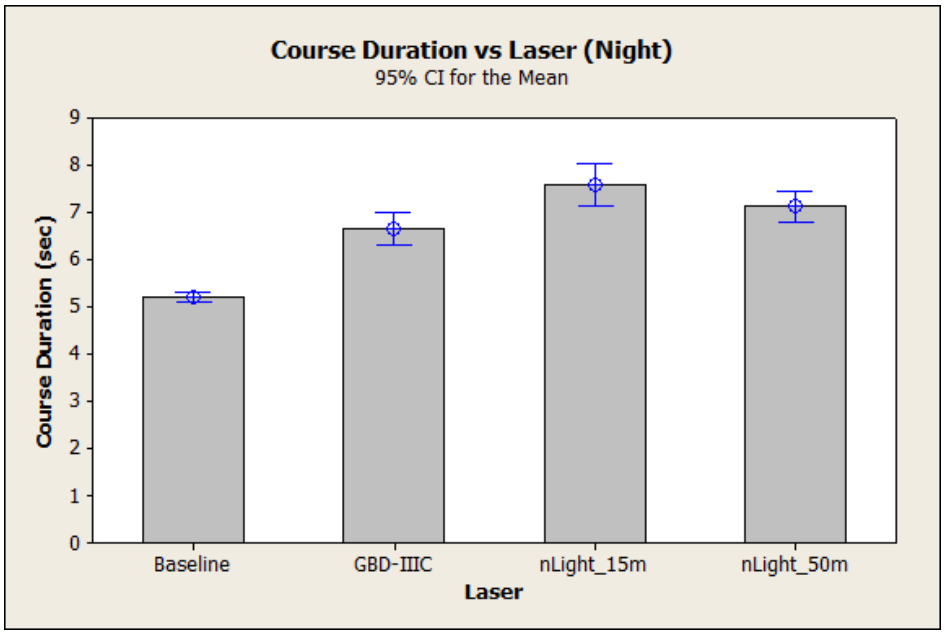
- Daylight: (5,650 – 78,500 lux)
  - No subject stopped, crashed or hit a barrier.
  - There was not a difference between the 3 laser conditions (p=0.906).
  - For first (novel) laser exposure, also no change in time (p=0.165).
- "Dusk" (12 - 3,020 lux)
  - No subject stopped, crashed or hit a barrier.
  - There was not a difference between the 3 laser conditions (p=0.168).
  - For first (novel) laser exposure, also no change in time (p=0.220).





Results: Suppress/Stop

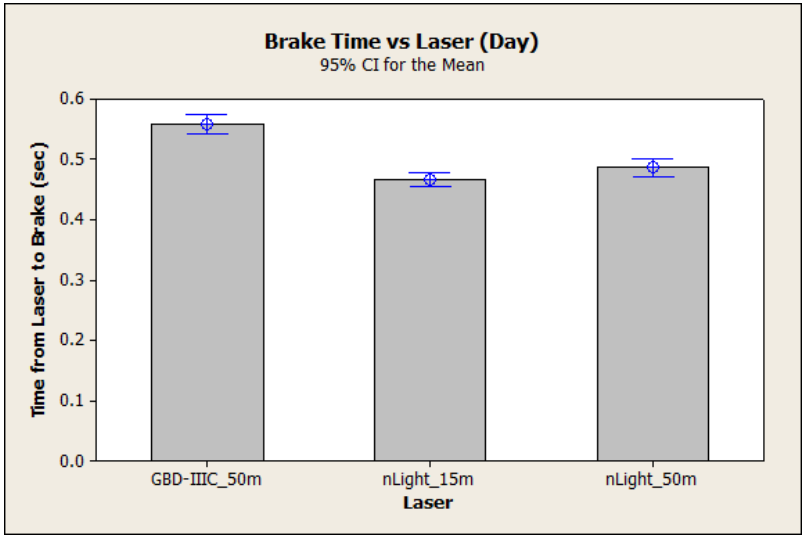
- Night (0 – 4 lux)
  - One person hit one cone on one trial, only condition where subjects ever stopped.
  - At respective NOHD, the nLight outperformed the GBD-IIIC (p=0.0069)
  - No difference between lasers at the same 50m (p=0.5609)
  - No detectable difference for nLight at 15m or 50m (p=0.5799)

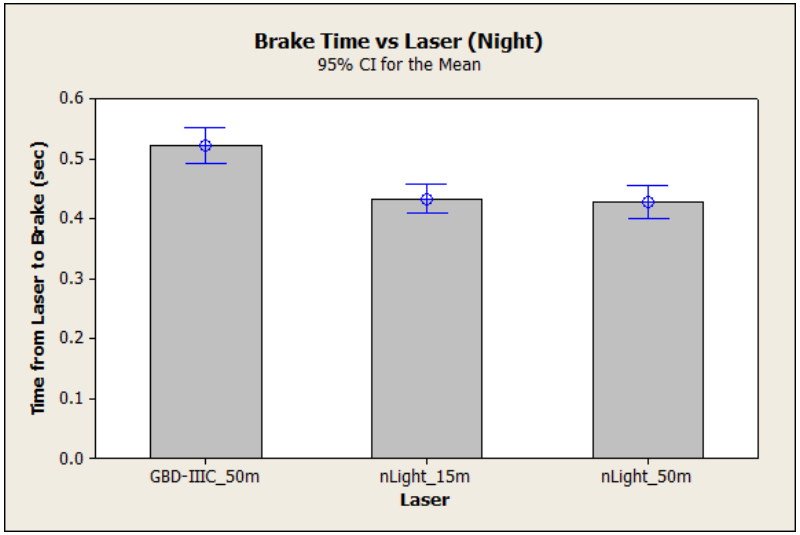


Results: Hail/Warn

- Day
  - Successfully complied 100% of trials when laser used, no errors.
  - There is reliable difference between braking time and laser ($p<0.0005$).

- Night
  - There is a reliable difference between laser conditions ($p<0.0005$).
  - GBD-IIIC has a longer braking time than the nLight ($p<0.0005$).
  - There is not a difference between the two distances of nLight ($p=0.8933$).





Conclusions

- Ambient light determines a green laser's ability to suppress drivers at checkpoints.
- Lasers can slow approaching drivers at low light levels (below 5 lux). But no effects observed for even moderate ambient light (10 lux +).
- No difference between the lasers at 50m, however the nLight can be used down to 15m, where it does have better performance than the GBD-IIIC.

- Subjects are capable of perceiving each of the green lasers and properly complying when they know what compliance is expected.
- Both lasers capable of signaling drivers.
- Drivers reliably reacted to the nLight roughly 1/10th second faster.

- Users should be instructed that hailing can occur during all hours but extensive public awareness is needed; suppression can only occur at night; and to expect at least a half second for the driver to react.

Questions

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