On-the-road driving tests and neurocognitive tests for measuring the effects of cannabis on driving

JG Ramaekers

Dept Neuropsychology & Psychopharmacology,
Faculty of Psychology & Neuroscience,
Maastricht University, The Netherlands
j.ramaekers@psychology.unimaas.nl

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Introduction

Cannabis – acute effects

- Does cannabis impair psychomotor, cognitive and actual driving performance and increase the risk of becoming involved in traffic accidents?
- Is there a relation between performance impairment and cannabis dose or its concentration in plasma?
- Do combined effects of cannabis and alcohol on driving performance differ from those of either drug alone?
- Limits of impairment

Introduction

Data sources

- Epidemiological surveys
  - Determine the involvement of THC users in traffic crashes
  - Prevalence data
  - Culpability data
  - Case Control data
- Experimental studies
  - Laboratory tests of isolated psychological functions related to driving
  - Driving simulators
  - Actual driving tests

Epidemiology

Prevalence data

Presence of THC is detected in 4-12% of drivers involved in traffic accidents

Caution !!!

Alcohol is also present in 50-80% of these THC positive drivers

Prevalence of THC in general driving population unknown (no control group)

Epidemiology

Culpability data

Classification of culpability

Distinguish between drivers who were responsible for their crash (Cases) and those who were not (Controls).

Compare culpability rates between THC users and drug free drivers that were involved in traffic accidents

(Odds Ratio or Culpability Ratio)

Epidemiology

Culpability data

Substance	Authors	Odds Ratio	95% CI
Drug free cases		1.0	
Alcohol	Terhune & Fell (1982);Williams et al (1985); Terhune et al (1992); Drummer (1994); Hunter et al (1998); Lowenstein & Koziol-McLain(2001); Drummer (2001)	3.2 * – 7.4 *	1.1 – 10.7
THC-COOH	Williams et al (1985); Drummer (1994); Hunter et al (1998); Lowenstein & Koziol-McLain(2001)	0.2 – 1.62	0.2 – 4.8
THC	Terhune & Fell (1982); Terhune et al (1992); Hunter et al (1998); Drummer et al (2004); Laumon et al (2006)	0.7 – 2.7 *	0.2 – 7.6
THC / Alcohol	Williams et al (1985); Terhune et al (1992); Drummer (1994); Hunter et al (1998); Lowenstein & Koziol-McLain(2001); Drummer (2004);	5.3 * - 19 *	1.9 – 136

Epidemiology

Culpability data

Substance	Authors	Odds Ratio	95% CI
Drug free cases		1.0	
THC concentration (ng/ml) in whole blood			
< 1.0	Hunter et al (1998)	0.35	0.02 – 2.1
1.1 – 2.0		0.51	0.2 - 1.4
>2		1.74	0.6 – 5.7
<5	Drummer et al (2004)	0.7	
5 - 100		6.6 *	1.3 - 116
< 1.0	Laumon et al (2006)	1.57	0.8 - 2.9
1 – 2		1.54	1.1 – 2.2
3 – 4		2.13	2.2 – 3.7
>5		2.12	1.3 – 3.4

Epidemiology

Case control

Substance	Authors	Number of cases and controls	THC /THC-COOH Odds rati0 (95% CI)
Mura et al (2003)	Prospective case control Injured drivers vs visitors of same hospitals	900- 900	2.5 (1.5-4.2)
Gerberich-Goodwin et al (2003)	Restrospective cohort in health care program Incidence of traffic injuries in cannabis users vs non users	64,657	2.3 (1.4-2.7)
Fergusson & Horwood (2001)	Retrospective cohort Self reported accident rate and cannabis use Adjusted for lifestyle	907 youngsters	1.6 (1.2 -2.0) 0.97 (0.9-1.1)
Dussault et al (2002)	Prospective case-control Injured drivers vs general driving population	354 –11,574	2.2 (1.5-3.4)
Movig et al (2004)	Prospective case-control Injured drivers vs general driving population	110 –816	1.2 (0.5-2.7)

Experimental studies

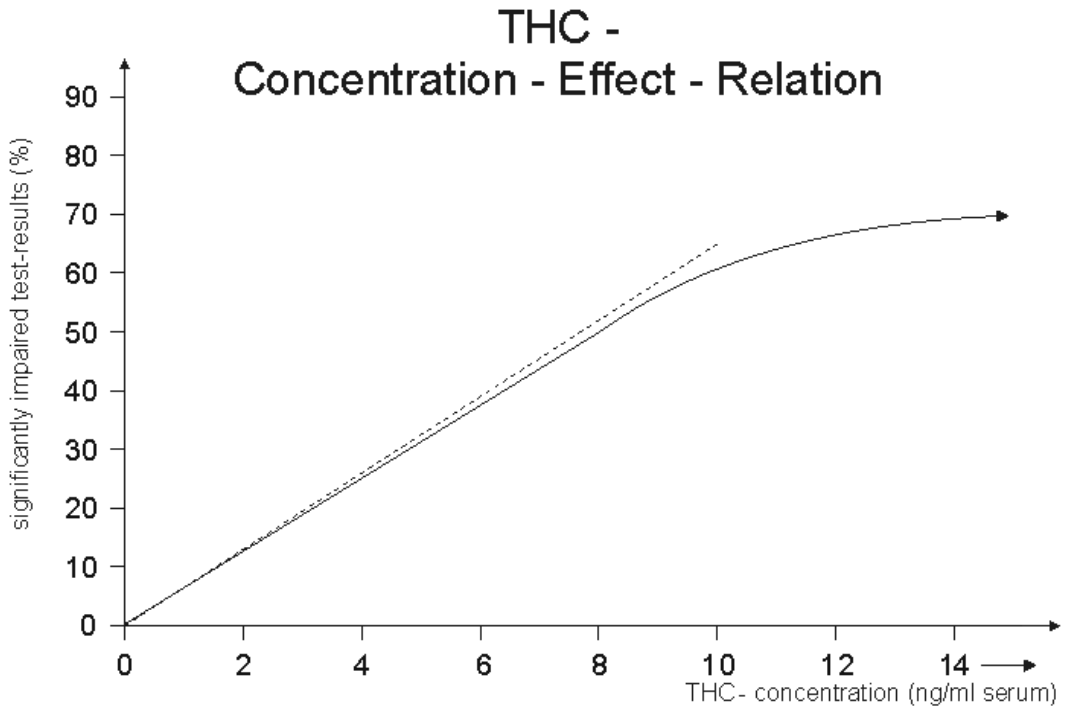
Psychomotor function and cognition

Numerous experimental studies have employed laboratory tests designed to measure cognitive and psychomotor skills related to driving.

- Memory
- Divided and Sustained attention
- Reaction time
- Tracking performance
- Motor control

Experimental studies

Psychomotor function and cognition



Frequency of performance decrements (%) observed in the total number of tests applied in 87 experimental studies as a function of THC concentration after eating (---) and smoking (-) cannabis (Berghaus et al, 1998)

Experimental

Construct validity laboratory tests

- Can results from experimental laboratory studies be generalized to on the road driving ?
- Are these tests relevant to driving ?

Experimental

On-the-road driving studies at Maastricht University (1990-2000)

- Funded by US NHTSA
- Rationale : to assess the effects of cannabis, alone and in combination with alcohol, on actual driving

Experimental studies

Actual driving tests

Driving models

- Road tracking performance

  e.g.. weaving, SDLP

- Car-Following performance

  e.g. brake reaction time, time to speed adaptation

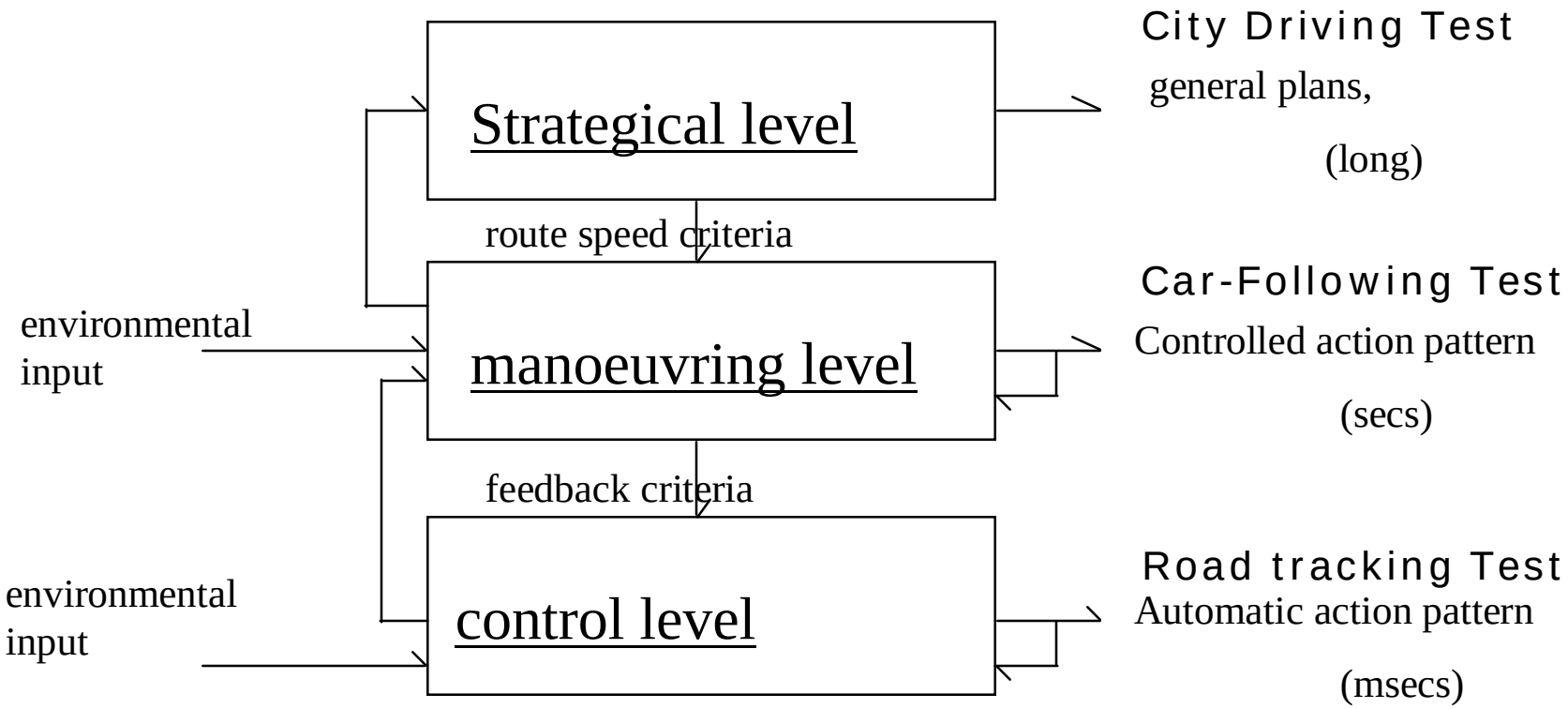
- City Driving performance

  e.g. visual search, anticipation traffic, decision making

The effects of cannabis on actual driving were most prominent in tests measuring road tracking precision as compared to tests measuring more complex driving tasks

Robbe (1994); Ramaekers et al. (2000); Lamers & Ramaekers (2001)

Actual driving tests



Experimental studies

Design interaction studies

Study 1

- Balanced 6-way, double-blind, placebo controlled, crossover design (N=18)
- dosages : 0, 100 and 200 µg/kg THC with and without 0.7 g/kg ethanol (mean BAC 0.04 g/dl)
- 19:00 hrs alcohol dose
  20:30 hrs THC smoking

  21.00-23.00 hrs Road Tracking/ Car-Following

Study 2

- Balanced 4-way, double-blind, placebo controlled, crossover design (N=18)
- dosages : 0, 100 THC w µg/kg with and without 0.7 g/kg ethanol (mean BAC 0.04 g/dl)
- 19:15 hrs alcohol dose
  20:00 hrs THC smoking

  20.30-21.30 hrs City Driving Test

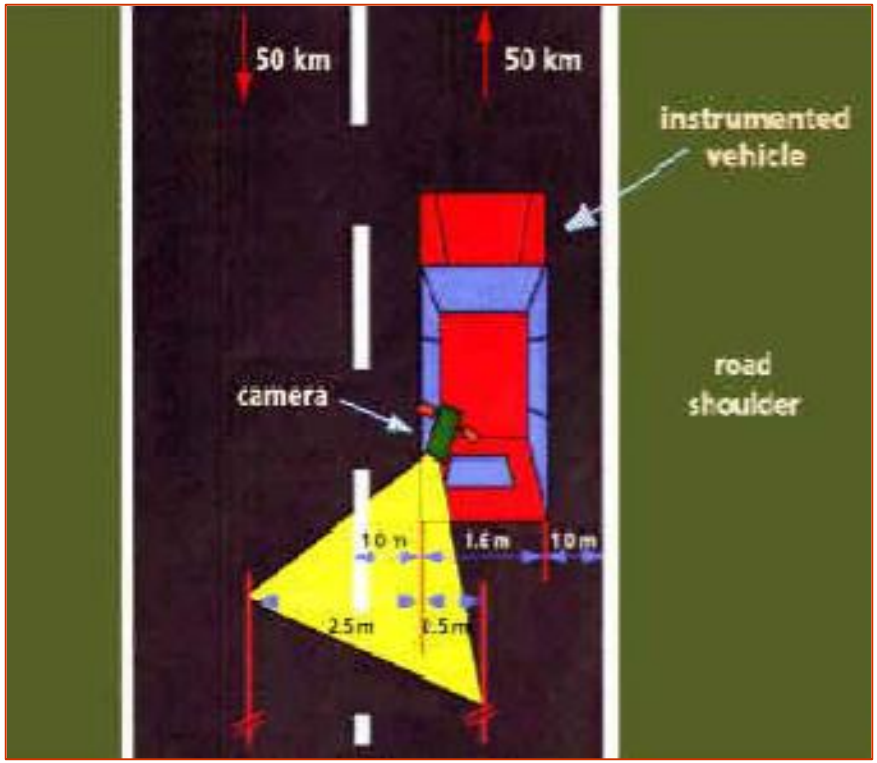
Experimental studies

Subject characteristics

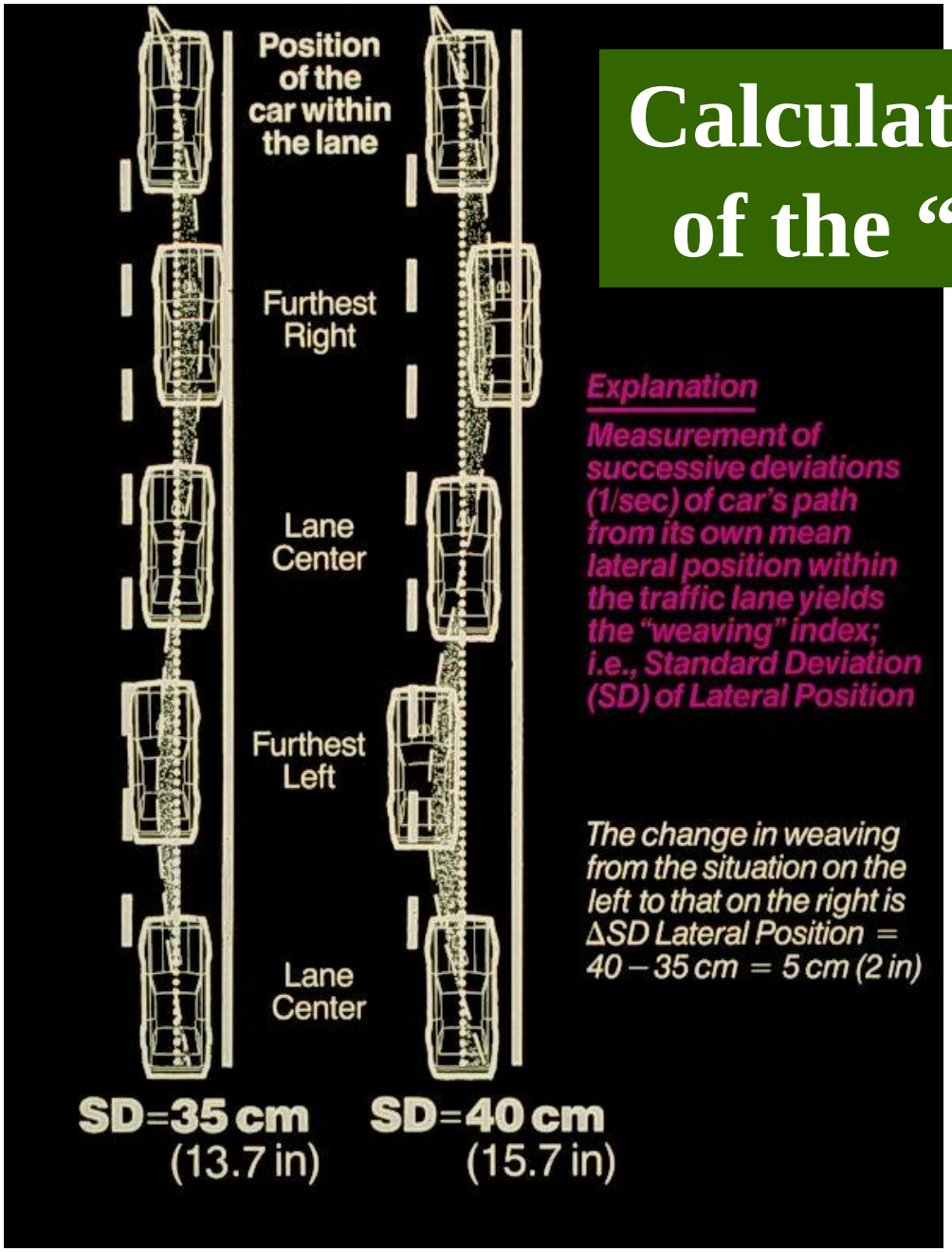
- Recreational users of cannabis and alcohol
- Physically and psychologically fit
- Age 21-40 years
- In possession of drivers 'licence
- Driven under the influence of cannabis and alcohol
- Dutch nationality

Experimental studies

Driving at the control level : Road Tracking Test



Calculation and meaning of the “weaving index”

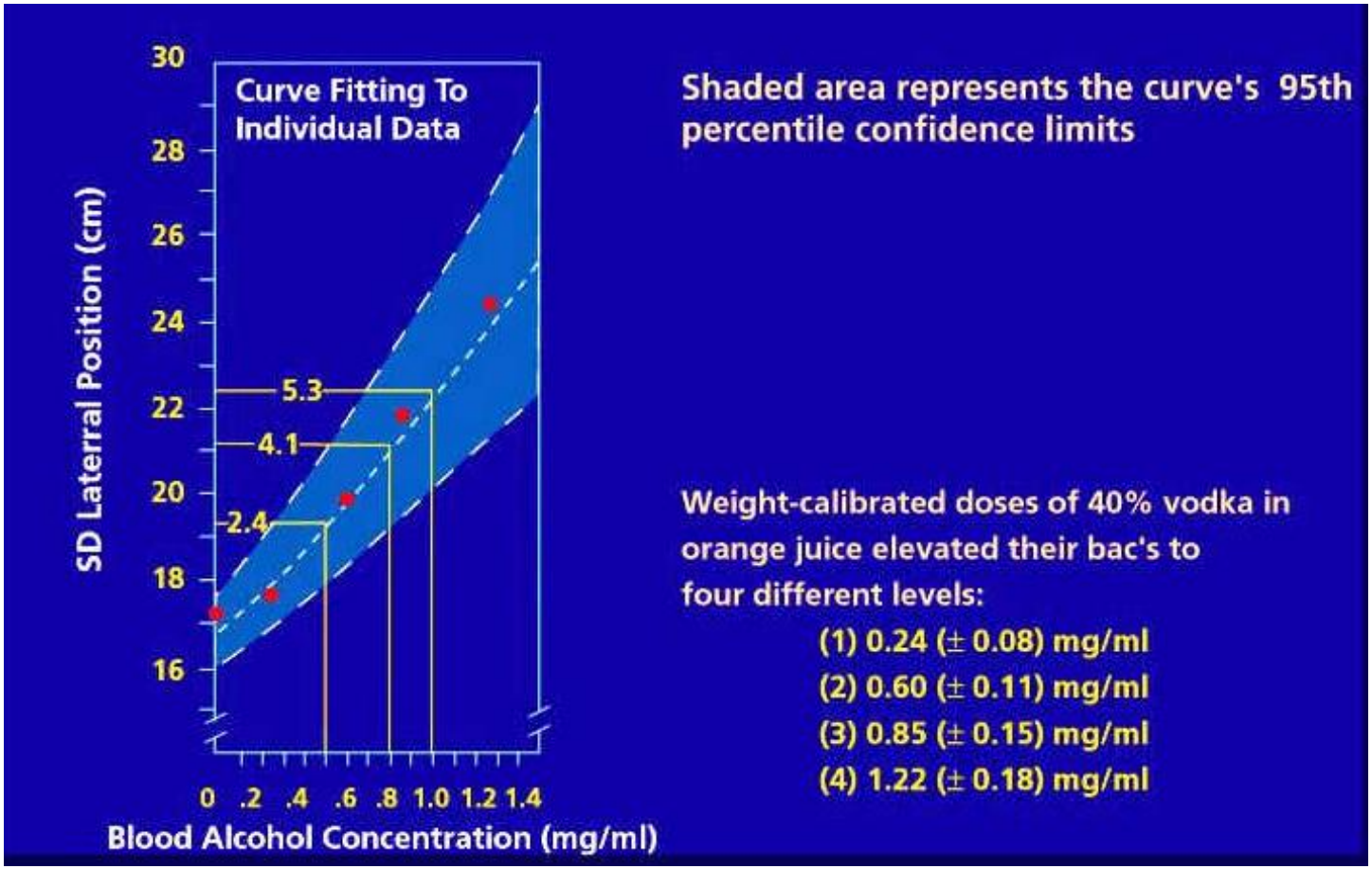


Experimental studies

Experimental studies

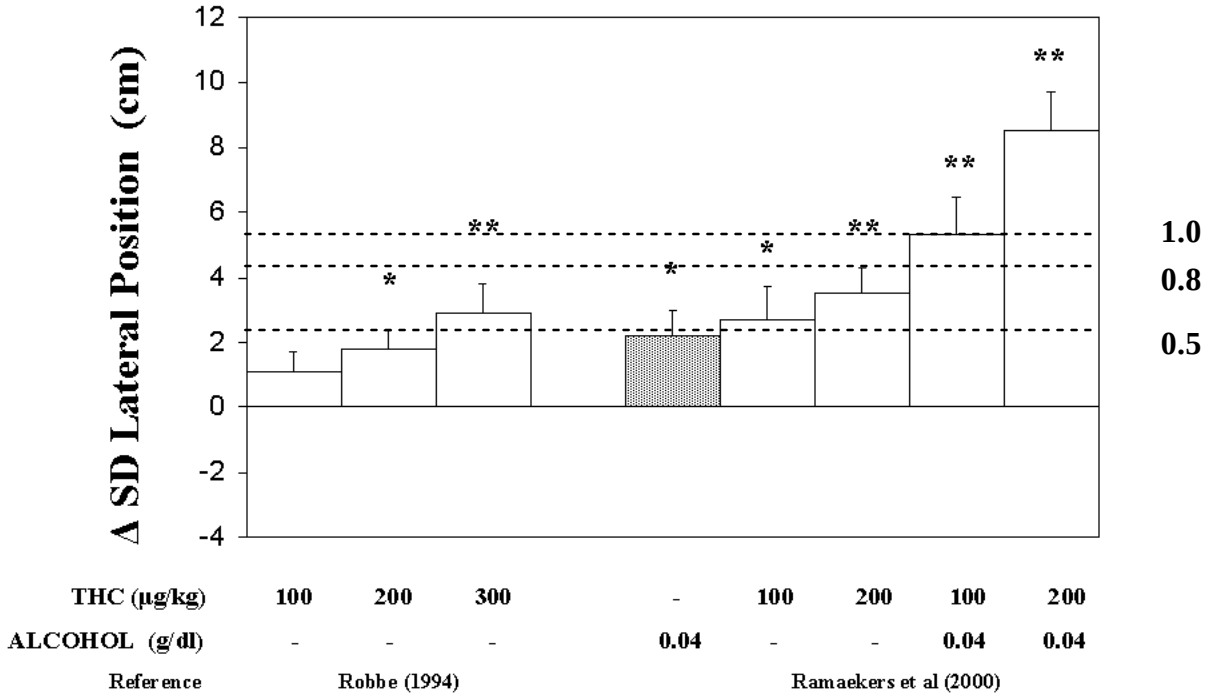
Mean SDLP as a function of BAC

SDLP change scores at legal BAC limits for driving under the influence in EC and US



Experimental studies

Road Tracking test



Equivalent effect of BAC (mg/ml)

Mean change in SDLP (weaving) in the Road Tracking Test after incremental doses of THC alone and after THC combined with alcohol.

Mean (range) plasma concentrations after 100, 200 and 300 microg/kg were: 7.9 (0.8-17.2), 12.0 (1.5-27.1) and 16.1 ng/ml (4.7-30.9) ng/ml

Experimental studies

Driving at the Manoeuvring Level

Car-Following Test

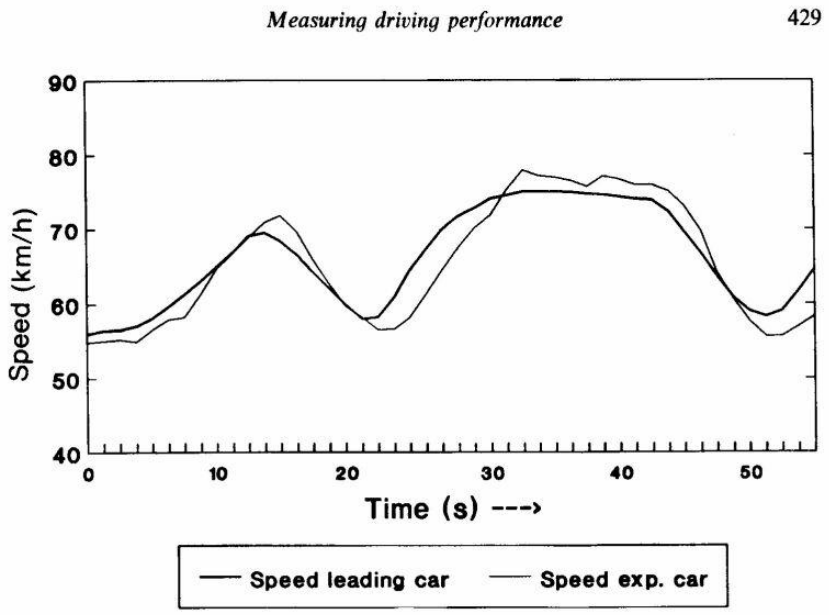
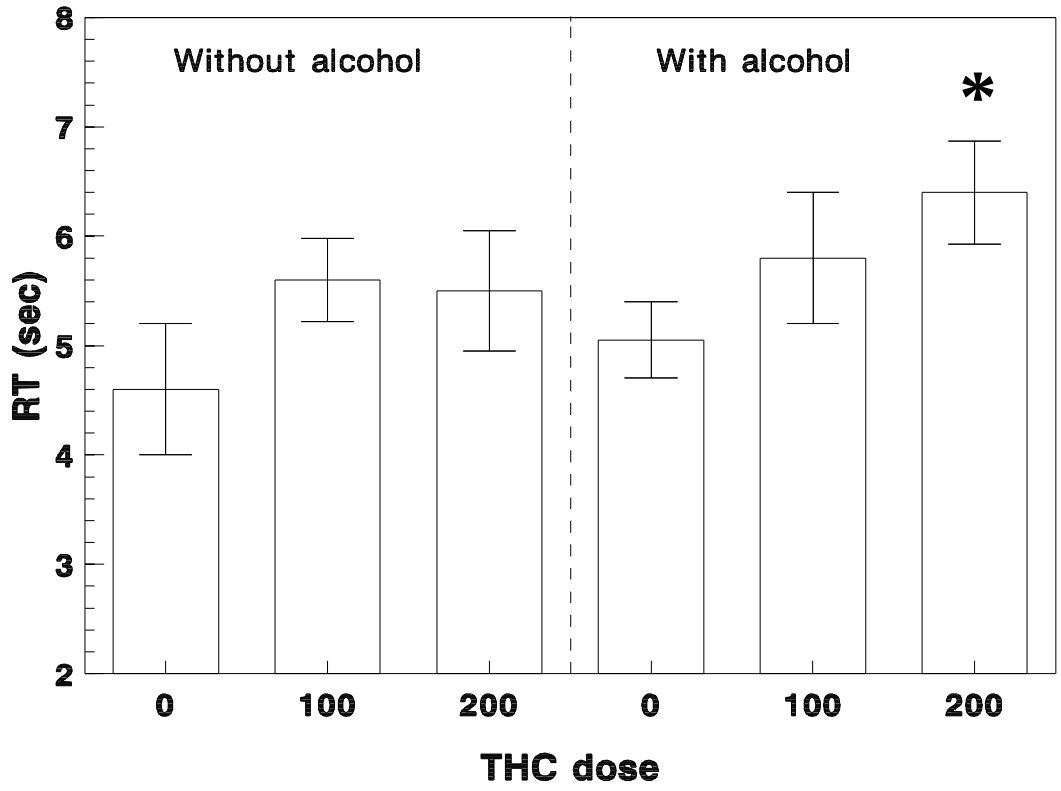


Figure 1. Representations of the speed of two instrumented vehicles in a car-following test.

Experimental studies

Car-Following Test



Mean (±SE) reaction time to speed decelerations in each treatment condition

Experimental studies

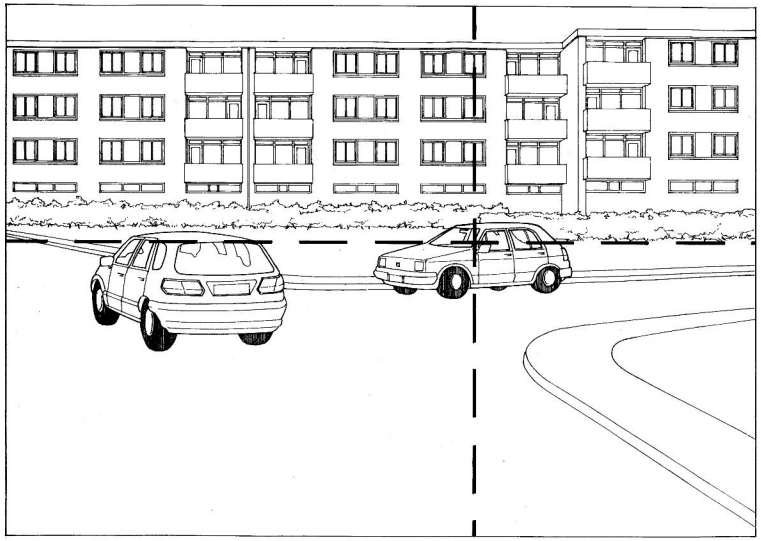
Driving at the Manoeuvring and Strategical level

City Driving Test

Central driving task: driving instructor ratings of vehicle checks, vehicle handling, traffic manoeuvres, observing and understanding traffic, turning

Experimental studies

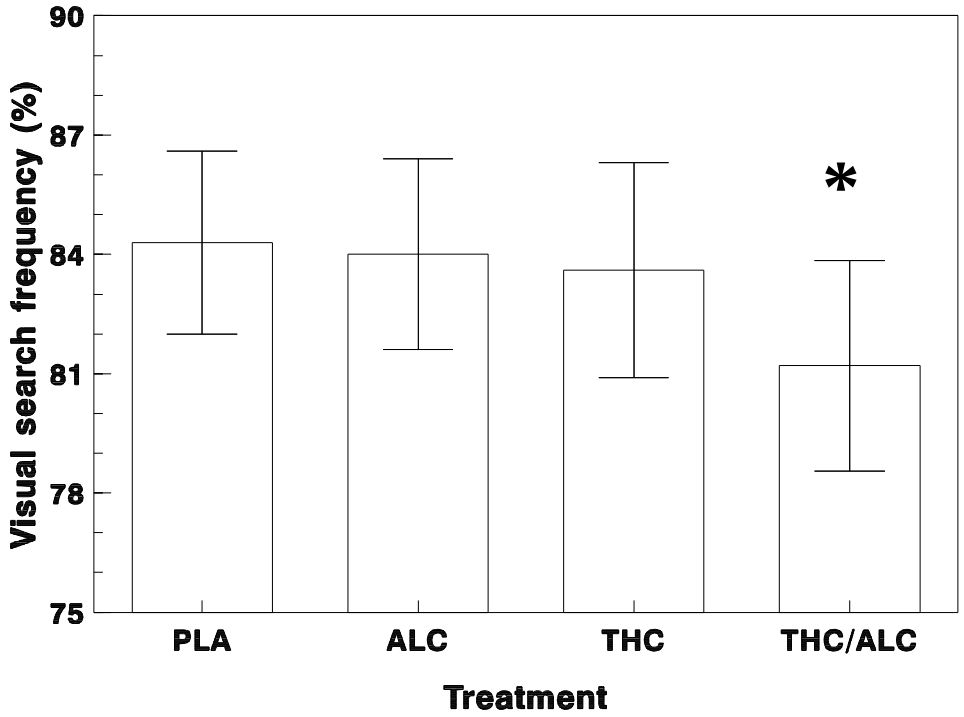
City Driving Test



***Peripheral driving task*: Eye movement recordings of visual search at intersections**

Experimental studies

City Driving Test



Mean (±SE) frequency of visual search for traffic at intersections in the City Driving Test by each treatment condition

Experimental studies

Overall

	Control Road Tracking	**Manoeuvring** Car Following	**Strategic** City Driving
THC 100	*	-	-
THC 200	*	-	
ALC	*	-	-
THC 100 /ALC	*	-	*
THC 200 / ALC	*	*	

summary

Conclusions from experimental studies

- THC has been shown to impair cognition, psychomotor function and actual driving performance in a dose related manner
- The degrees of impairment observed in laboratory or actual driving tests after doses of up to 300 μg/kg THC were comparable to the impairing effects of a dose of alcohol producing a BAC ≥0.05 g/dl, the legal limit for driving under the influence in most European countries.
- Combined use of THC and alcohol severely impairs driving performance, even at low doses.

Summary

… and epidemiological studies

- There is no indication that *past use* of THC alone affects crash risks, but there is growing evidence that *recent use* of THC increases the risk of culpability for motor vehicle accidents compared to drug free drivers, particularly at higher concentrations.
- Combined use of THC and alcohol sharply increases the risk of drivers 'culpability for accidents as compared to drug free drivers, even at low doses.