Drunker Than You Think: Delayed Performance Impairment from Moderate Amounts of Alcohol

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TARS
Traffic and Road Safety Research Group
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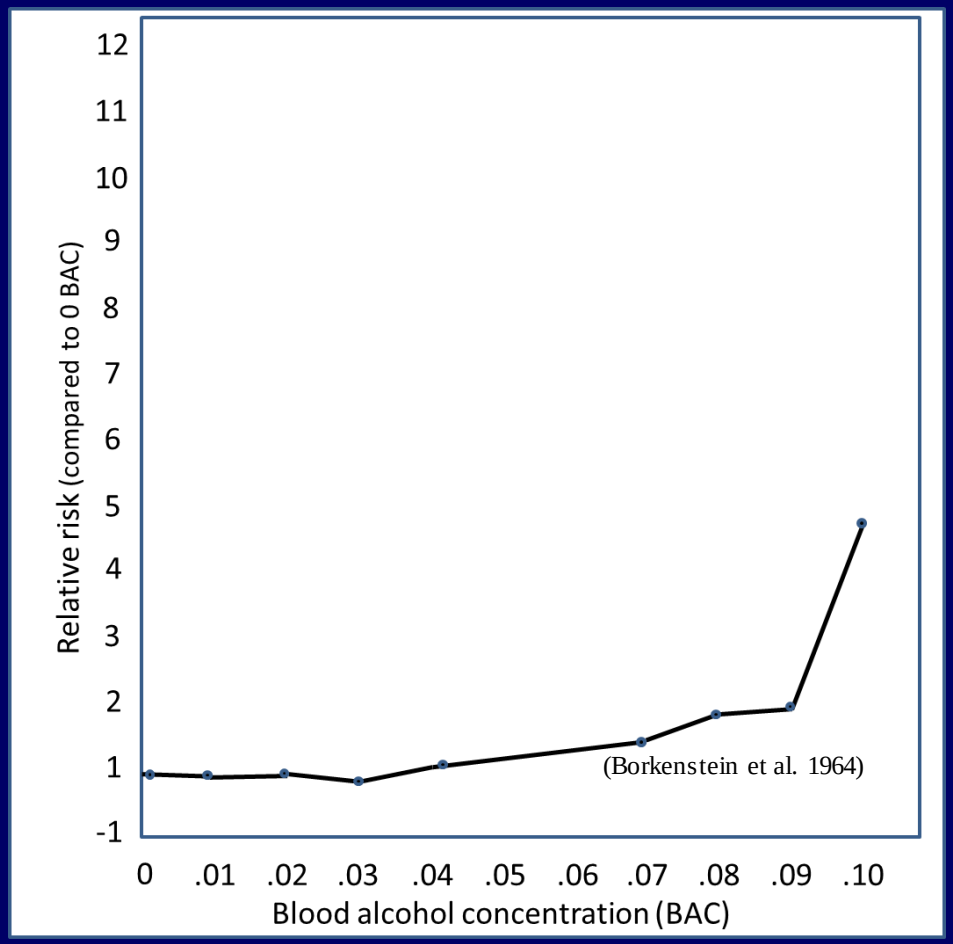
Background

The Grand Rapids Study -- large case-controlled study on alcohol and driving

found a high elevation in crash risk (4.79) associated with a BAC of .10

(Borkenstein et al. 1964)



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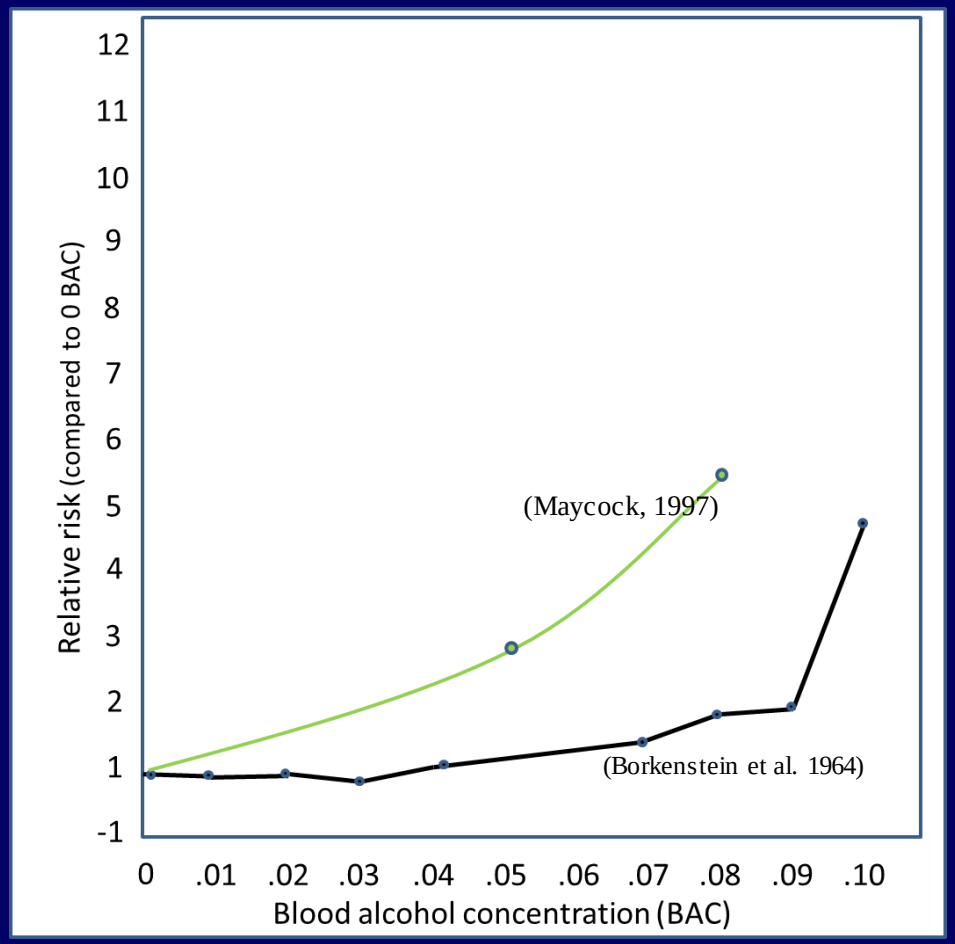
Risk of injury accident is 2.9 times greater at BAC of .05 and 5.6 times greater at a BAC of .08

(Maycock, 1997)



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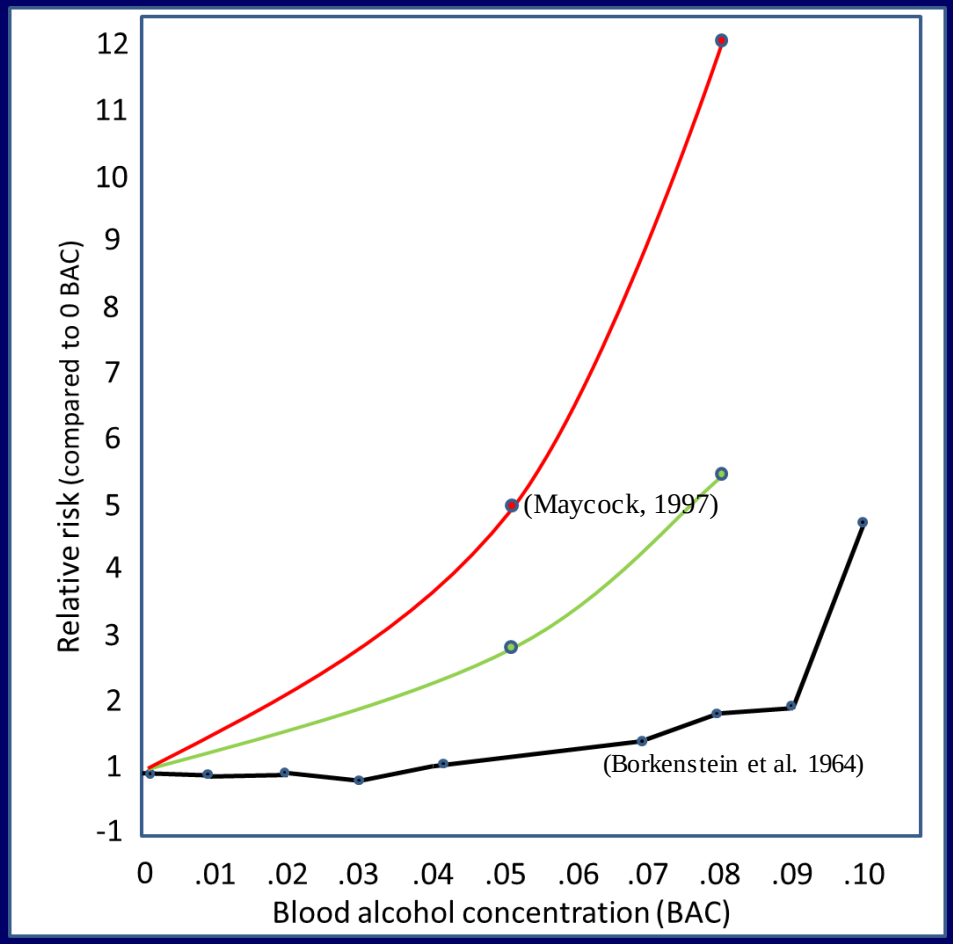
Risk of injury accident is 2.9 times greater at BAC of .05 and 5.6 times greater at a BAC of .08

(Maycock, 1997)

Risk of a fatal crash at .05 is 5.0 times and at .08 BAC it is 12.4

(Maycock, 1997)



Wide range of BAC limits in legislation

Zero

Bangladesh
Brazil
Czech Republic
Fiji
Hungary
Paraguay
Romania
Slovakia

0.02%

China
Estonia
Poland
Sweden

0.03%

Belarus
Chile
India
Serbia
Japan
Russia (2013)

0.05%

(modal limit)
Argentina
Australia
Austria
Belgium
Bulgaria
Canada
Costa Rica
Denmark
Finland
France
Germany
Greece
Iceland
Ireland
Italy
Latvia
Netherlands
Peru
Philippines
Portugal
⋮

0.08%

England
Malaysia
Mexico
New Zealand
Scotland
United States
(formerly .1 to .15)
Wales

Wide range of beliefs about how much alcohol it takes to reach BAC limits

"I've read that even just 1 beer is enough to put you past the legal amount. And it is true that certain beers are stronger than others"

"It depends on many different factors. Body weight, type of alcohol, sex, etc. I think that usually it is two beers/shots for men and 1 shot/beer for women"

"A 120-pound woman can reach a .08 BAC level after only two drinks and a 180-pound man can be at .08 after only four drinks"

"To reach a BAC of .08, an average 170-pound male would have to down more than four drinks within one hour on an empty stomach, while an average 137-pound female would need to take in at least three drinks in an hour"

Alcohol effects are not uniform across cognitive functions

BAC AND IMPAIRMENT, BY BEHAVIORAL AREA		
BAC (g/dl)	**By Lowest BAC at Which Impairment Was Found**	**By First BAC at Which 50% or More of Behavioral Tests Indicated Consistent Impairment**
0.100	Critical Flicker Fusion	Simple RT, Critical Flicker Fusion
0.090-0.099		
0.080-0.089		
0.070-0.079		
0.060-0.069		Cognitive Tasks, Psychomotor Skills, Choice RT
0.050-0.059		Tracking
0.040-0.049	Simple RT	Perception, Visual Functions
0.030-0.039	Vigilance, Perception	Vigilance
0.020-0.029	Choice RT, Visual Functions	
0.010-0.019	Drowsiness, Psychomotor Skills, Cognitive Tasks, Tracking	Drowsiness
0.001-0.009	Driving, Flying, Divided Attention	Driving, Flying, Divided Attention

(Moskowitz & Fiorentino, 2000)

Alcohol effects are not uniform across different aspects of driving

Driving speed is not affected at BAC of .05

(West et al 1993)

Impairment in vehicle detection at BAC of .06

(Leung and Starmer, 2005)

Increased risk taking and poorer driving at BAC of .09

(line crossings, speed, & stopping failures)

(Fillmore et al, 2008)

Dose-dependent impairment on SDLP but not speed control at BACs of .05 to .11

(Mets et al, 2011)

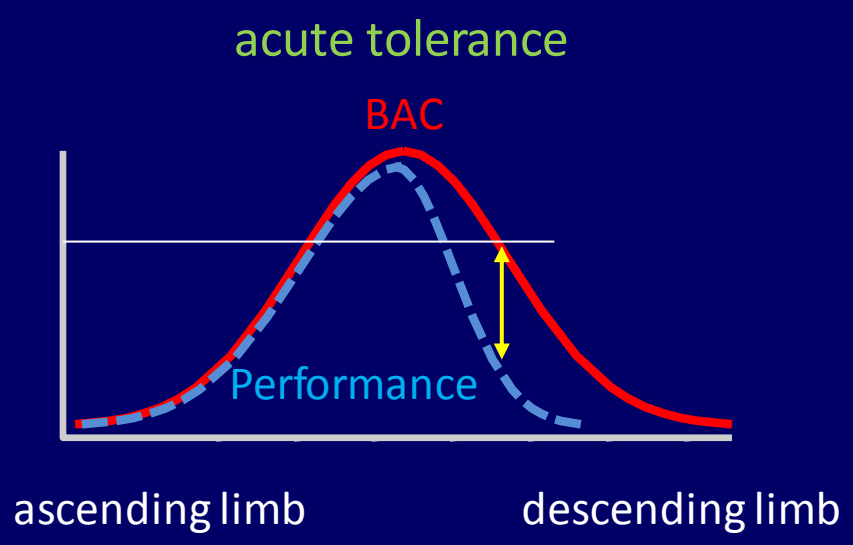
No impairment reacting to a car pulling out, running red lights or frequency of crashes for BAC of .08

(Veldstra et al 2012)

Alcohol effects are not uniform across time

Acute tolerance effects

lower impairment on the descending limb of the intoxication curve as compared to the same BAC on the ascending limb



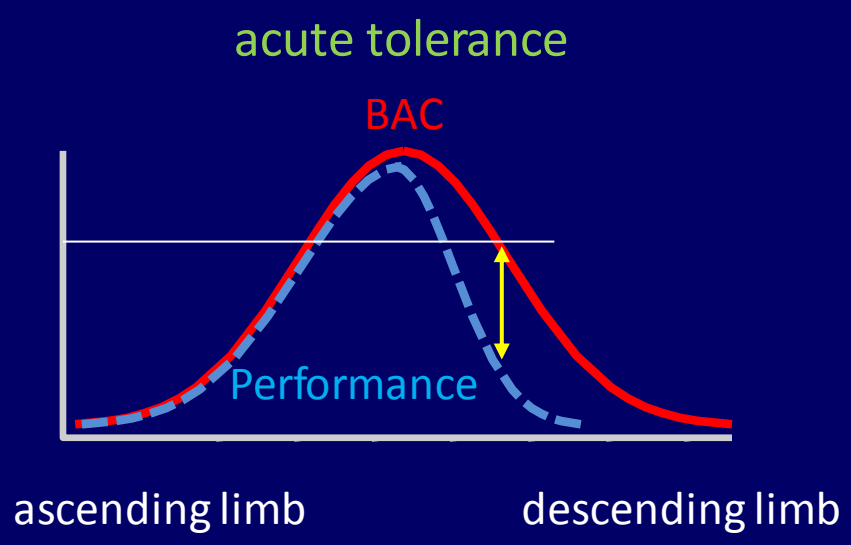
Alcohol effects are not uniform across time

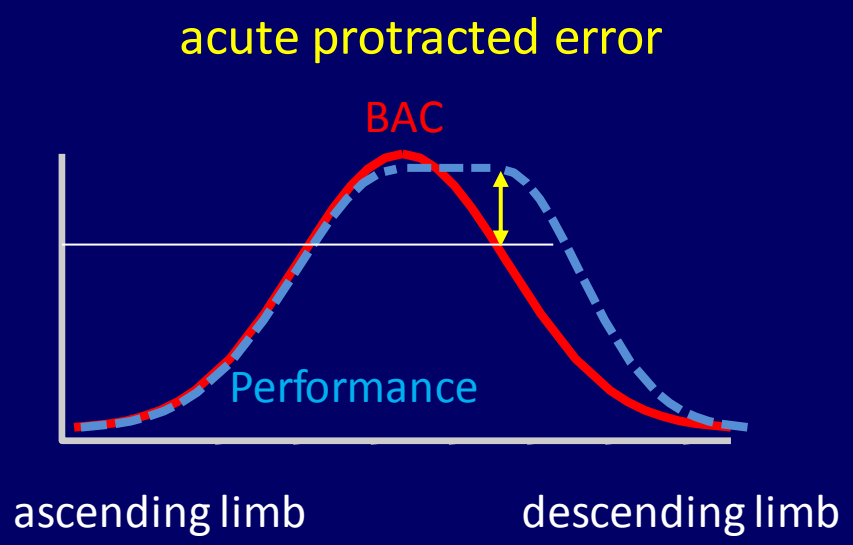
Acute tolerance effects

lower impairment on the descending limb of the intoxication curve as compared to the same BAC on the ascending limb

Acute protracted error

greater impairment on the descending limb of the intoxication curve as compared to the same BAC on the ascending limb





Present study -- Research goals

1. Evaluate the effects of different alcohol levels on psychomotor, cognitive, and driving performance

2. Identify the relationship between drivers' self-perception of intoxication and the actual level of performance impairment produced

Method

Three alcohol dose groups:
placebo, medium (.05), or high (.08)

61 participants tested over 3.5 hours with cognitive, driving, psychomotor, & subjective measures

Participants

61 participants 33 males 28 females
average age of 31.11 years (SD = 8.34)

Recruitment criteria:
Aged 20-50
Full NZ drivers licence
In good health (no neurological /psychological conditions, no contra-indicated medication)
Drink occasionally but not excessively (AUDIT score <8)

Alcohol Use Disorders Identification Test (AUDIT)
10 item screening test recommended by World Health Organisation

Received $60 in gift vouchers
($10 for familiarisation, $50 for full session)

Cognitive Performance Measures
CogState test battery

Groton Chase Task – participant "chases" a target across a 10 x 10 grid of tiles on the computer screen by tapping on tiles
assesses visual motor function (1 min)

Groton Maze Learning Task – participants uncover a 28 step hidden pathway across a 10 x 10 maze of tiles
the same maze was repeated 4 more times
assesses visual motor function, executive function, visual learning, memory (4.5 min)

Card identification Task – choice RT task with virtual stack of playing cards
assesses attention & vigilance (1 min)

Groton Maze Recall Task – participants recall previous 28 step hidden pathway (1.5 min)

Total: 8 min

Driving Performance Measures

TARS driving simulator

11 km-long section of rural road, 5 different backgrounds

- Standard deviation of lane position (SDLP)
- Centreline crossings (number & total sec)
- Edge line crossings (number & total sec)
- Standard deviation of speed (SDS)
- Time over speed limit (sec)
- Peak speed (km/h)

20 intersections with vehicles waiting

At 6 intersections, a vehicle waiting on the left moved 2.6 m forward [at 1 m per sec] to partially obstruct the driver's lane

Participants instructed to flash their lights when they detected a vehicle pulling out in front of them, then brake and steer to avoid hitting the car

Driving Performance Measures

TARS driving simulator

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Standard deviation of lane position (SDLP)
Centreline crossings (number & total sec)
Edge line crossings (number & total sec)

Standard deviation of speed (SDS)
Time over speed limit (sec)
Peak speed (km/h)

20 intersections with vehicles waiting

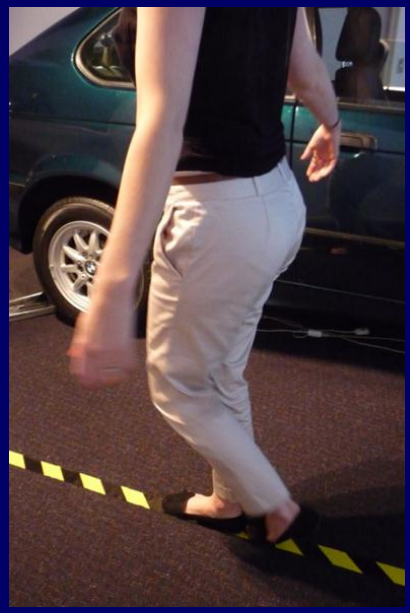
At 4 intersections, "false alarm" vehicles that moved 0.8 m in 1 sec did not obstruct the driver's lane

Participants instructed to not to flash their lights for "false alarm" cars

Total: 8 min

Participants breathalysed after CogState and again after drive

Alcomate AccuCell AL9000 professional grade breathalyser (sensor accuracy of +/- 0.005%)



Followed by walk and turn portion of Police Field Sobriety Test

(total errors) 2 min

and self-ratings of intoxication, willingness to drive, & sleepiness

1 min

Subjective Rating Scales

Subjective Perception of Intoxication (Cromer et al, 2010)

How intoxicated do you feel right now?

Least intoxicated ever felt — Most intoxicated ever felt

Willingness to Drive Rating (Marczinski & Fillmore, 2009)

How would you rate your willingness to drive at the current time?

Not at all willing — Very willing

Karolinska Sleepiness Scale: Likert scale (Friedman et al, 2011)

How sleepy do you feel right now?

1	2	3	4	5	6	7	8	9
Very alert				Not sleepy or alert				Very sleepy

Alcohol Administration

No food three hours prior to session
(Breakfast allowed but no caffeine)
No alcohol the night before

Target BAC	Females	Males
.05	.60 g/kg	.75 g/kg
.08	.75 g/kg	1.0 g/kg
Placebo	15 ml floated on top of each drink (same volume of fluid as other groups)	

30% vodka, 70% orange juice divided equally across three drinks

Two drinks given after baseline testing,
5 minutes to consume each drink

Third drink given 35 mins later unless BAC within .01 of target

Full session test protocol

(approx 3.5 hrs)

Practice Drive

Block 1 – Baseline (pre-drink)

Drink 1 & 2 (5 mins each)

Block 2 – Ascending (15 mins after drinks served)

Optional 3rd drink (35 mins after first drinks)

Block 3 – Peak 1 (45 mins after drinks)

Block 4 – Peak 2 (1 hr 15 after drinks)

Rest break approx 55 mins, snacks

Block 5 – Descending (2 hr 30 after drinks)

Estimation of alcohol consumption

Debriefing

Taxi home

Drink Estimation

Estimated number of standard drinks consumed

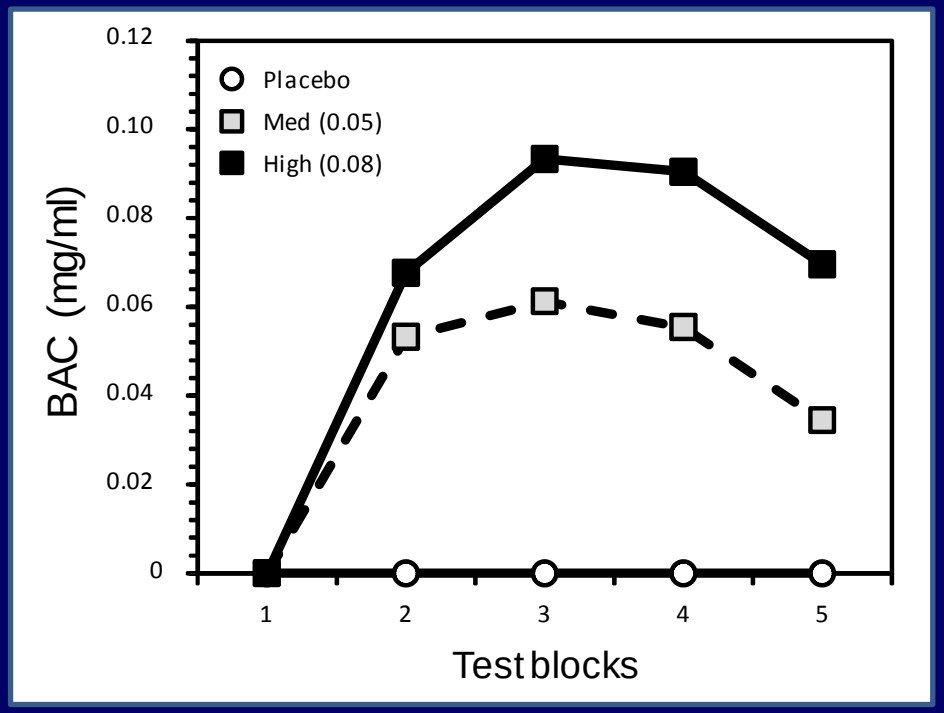
Group*	Females		Males	
.05	3.37	3.78	4.25	5.60
.08	2.72	4.81	5.30	9.01
Placebo	1.42			

Actual number of standard drinks consumed

**Significant group difference* $F(2, 55) = 19.86$, $p < .001$, $\eta_p^2 = .419$

Results

Effect on BAC



Significant group difference Blocks 2-5, p < .001

Post hoc pairwise comparisons (Bonferroni)
all groups significantly different, p < .001

Results

Selected test blocks to compare equivalent BACs for each participant

(to compare ascending and descending limbs)

	Mean BAC		
	Ascending	Descending	n
Placebo	0 (Block 3)	0 (Block 4)	20
Gp2	0.056	0.053	14
Gp3	0.094	0.092	15

6 measures showed symmetric alcohol effects

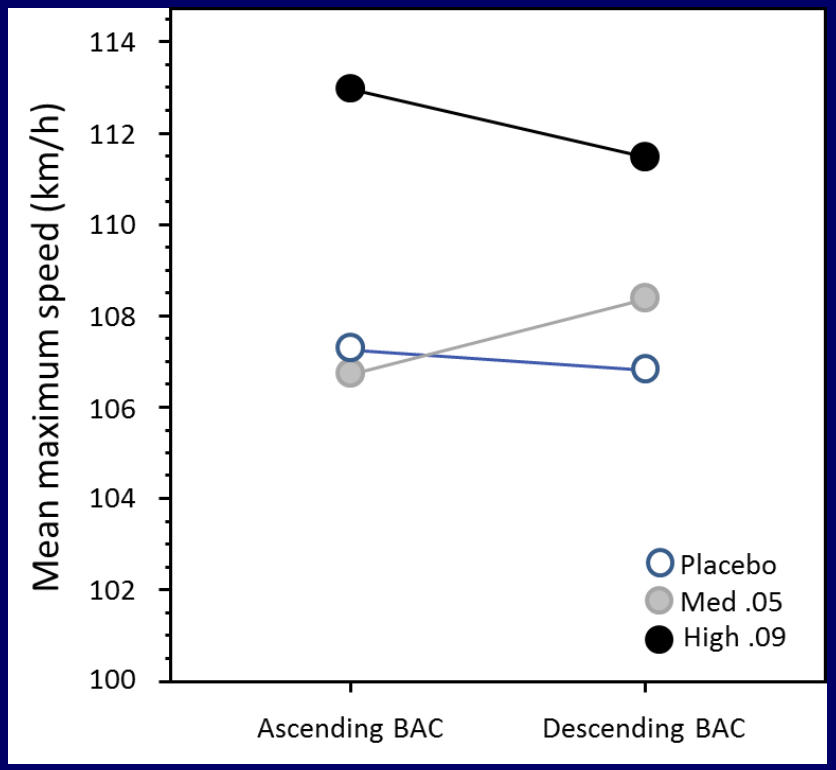
(no difference between ascending and descending limbs)

3 measures showed acute tolerance

6 measures showed acute protracted error

Symmetric Alcohol Effects

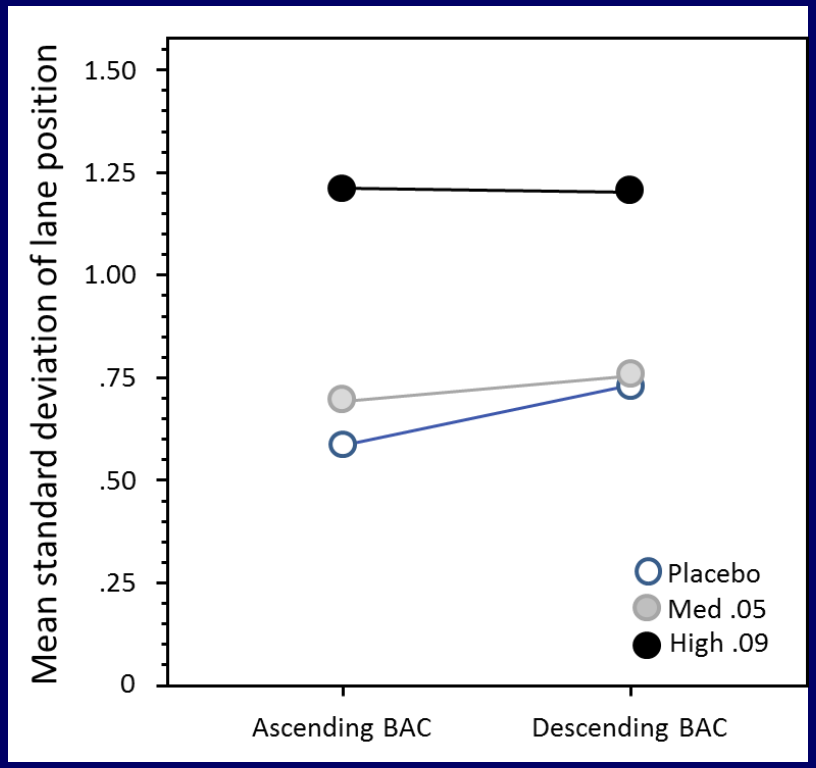
Maximum speed



Significant BAC effect

$F(2,45) = 10.994$, $p < .001$, $\eta_p^2 = .328$

SDLP

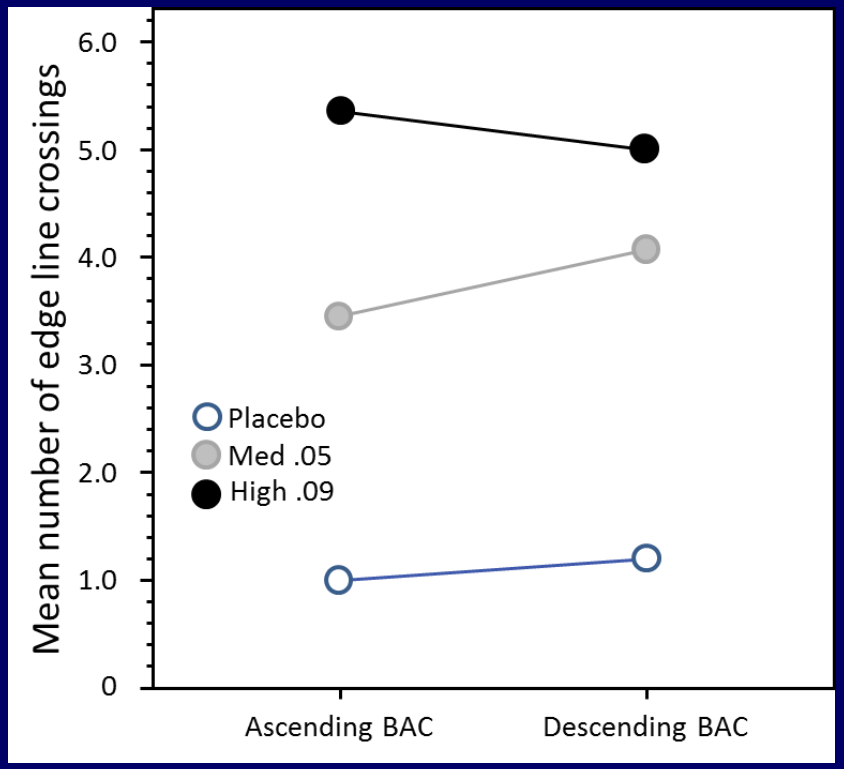


Significant BAC effect

$F(2,45) = 3.477$, $p = .039$, $\eta_p^2 = .134$

Symmetric Alcohol Effects

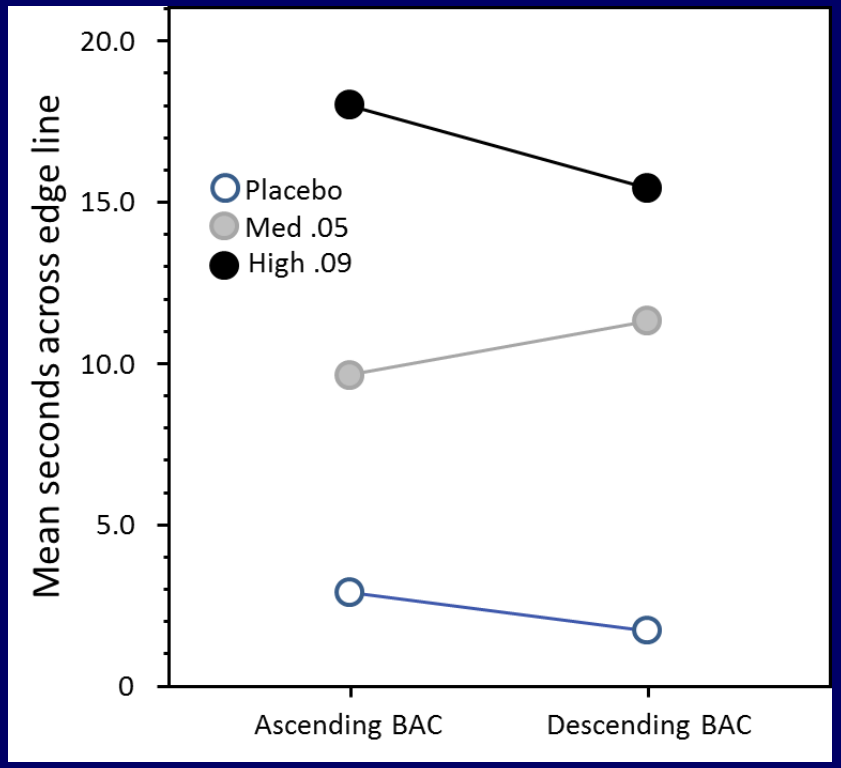
Edge line crossings



Significant BAC effect

$F(2,45) = 5.968$, $p = .005$, $\eta_p^2 = .210$

Sec over the edge line

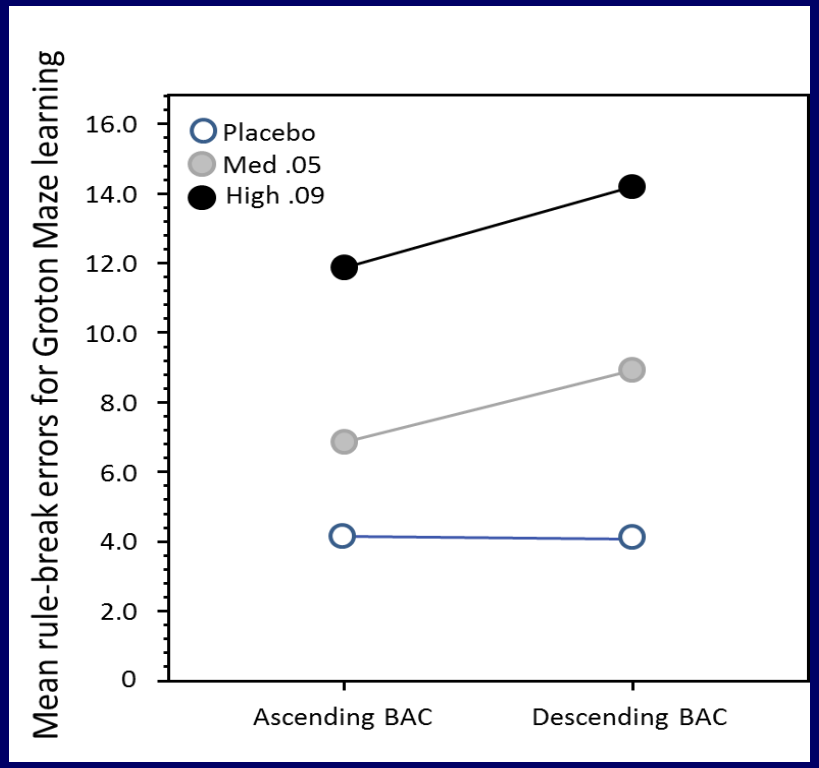


Significant BAC effect

$F(2,45) = 5.332$, $p = .008$, $\eta_p^2 = .192$

Symmetric Alcohol Effects

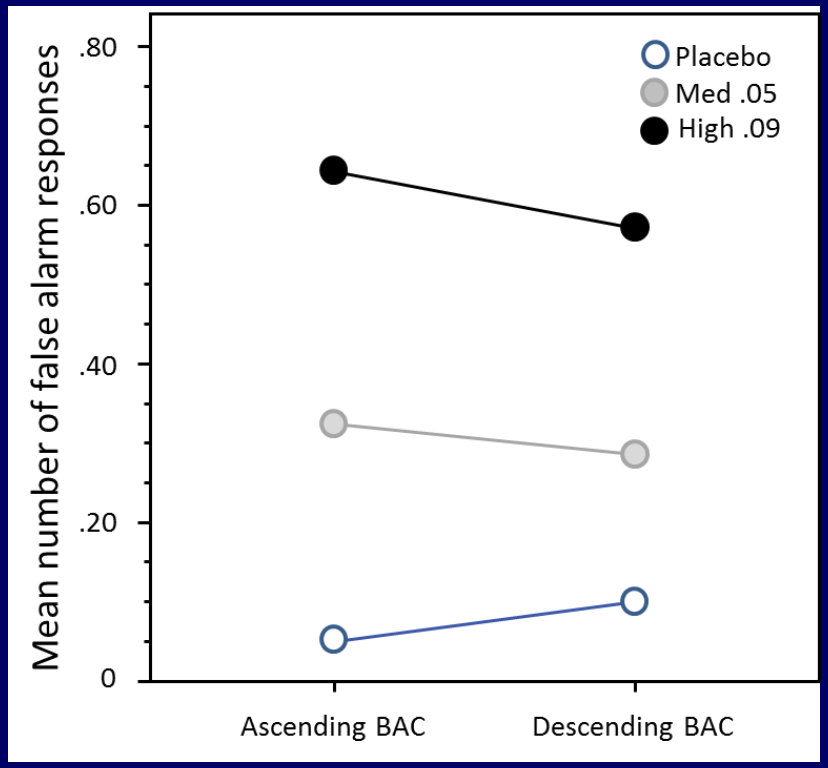
Groton Maze rule break errors



Significant BAC effect

$F(2,46) = 6.609$, $p = .003$, $\eta_p^2 = .223$

False alarm responses

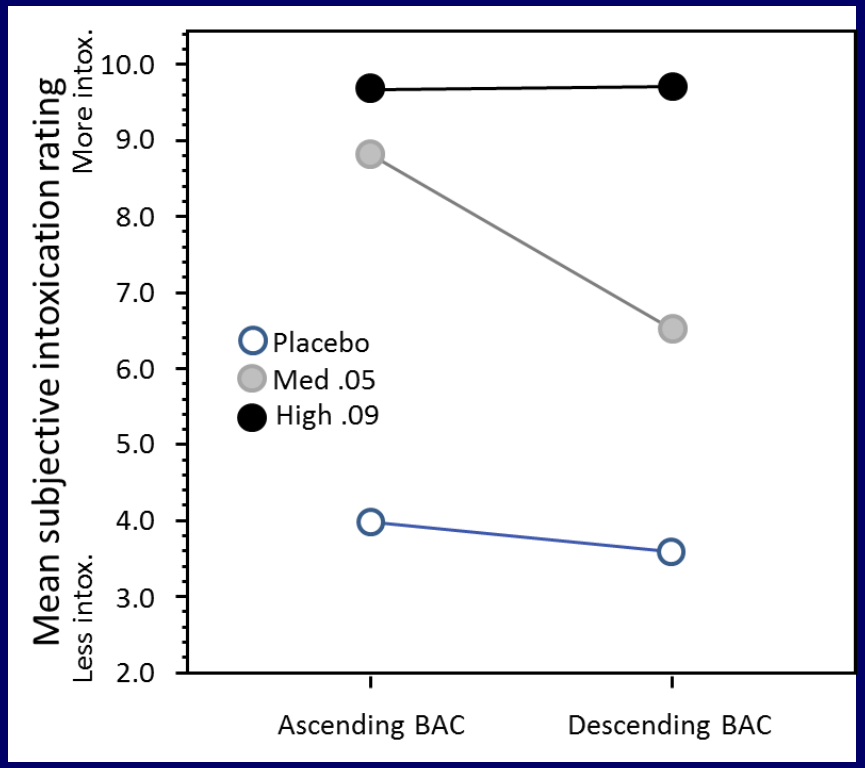


Significant BAC effect

$F(2,45) = 4.168$, $p = .022$, $\eta_p^2 = .156$

Acute Tolerance Effects

Subjective intoxication rating



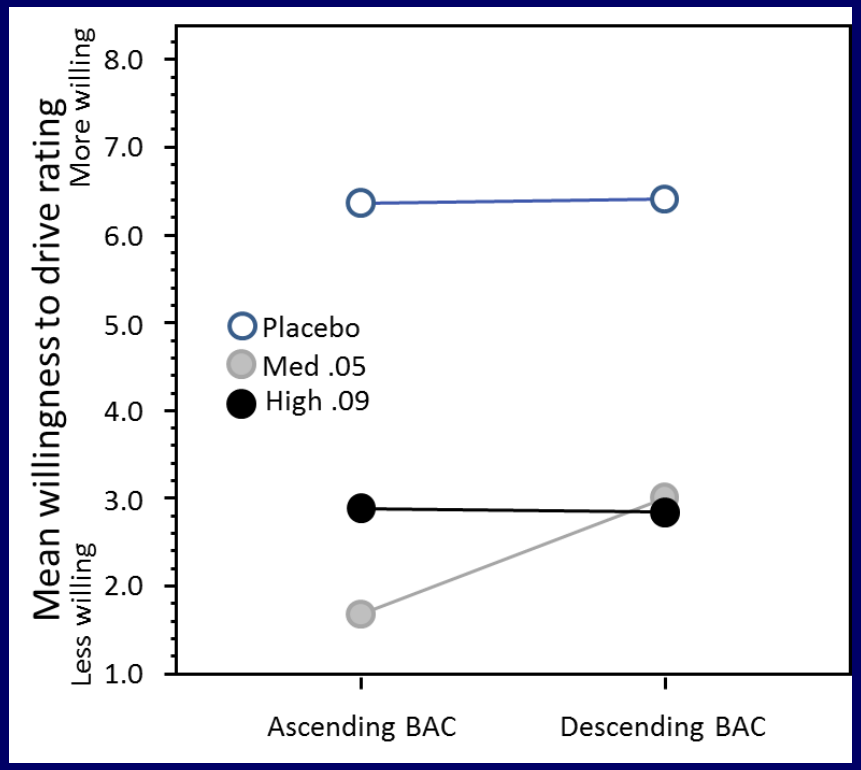
Significant phase effect

$F(1,46) = 4.465$, $p = .040$, $\eta_p^2 = .088$

Significant BAC effect

$F(2,46) = 13.890$, $p < .001$, $\eta_p^2 = .377$

Willingness to drive rating



Significant BAC X phase interaction

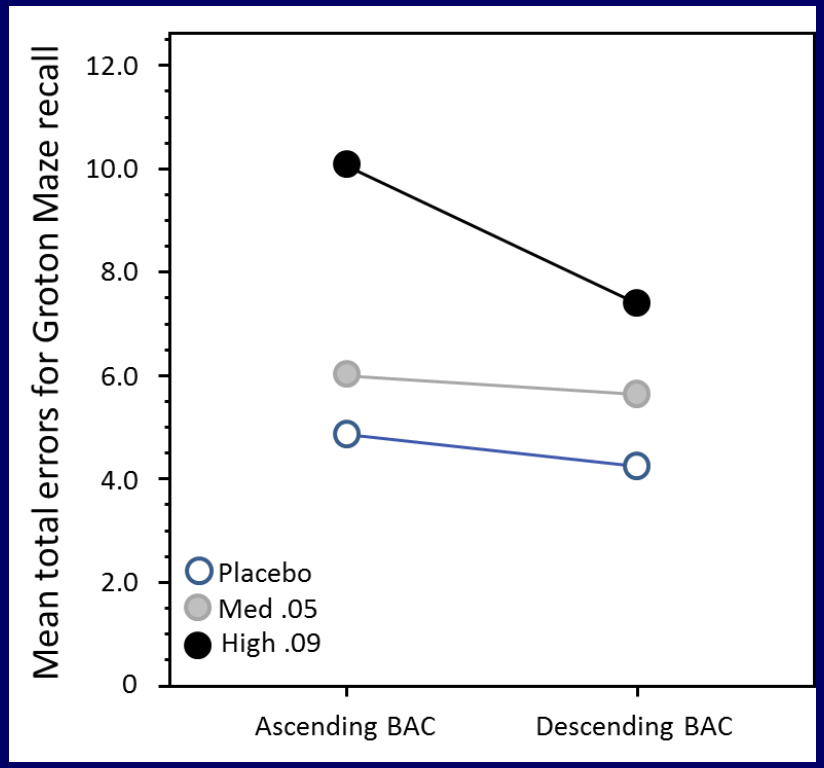
$F(2,46) = 3.005$, $p = .059$, $\eta_p^2 = .116$

Significant BAC effect

$F(2,46) = 10.754$, $p < .001$, $\eta_p^2 = .319$

Acute Tolerance Effects

Groton Maze recall errors



Significant phase effect

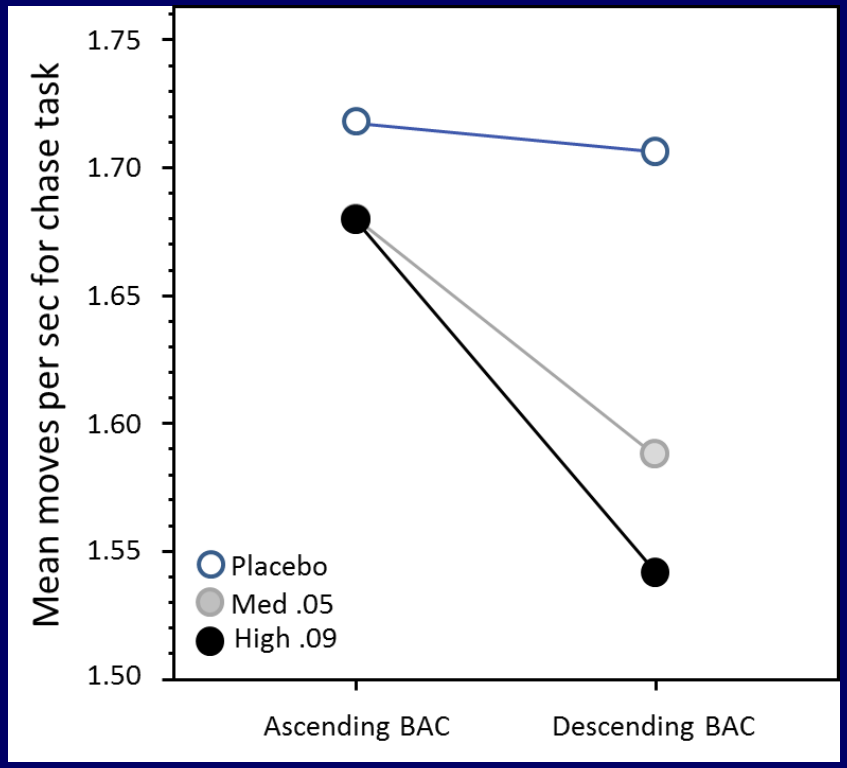
$F(1,46) = 3.591$, $p = .064$, $\eta_p^2 = .072$

Significant BAC effect

$F(2,46) = 4.837$, $p = .012$, $\eta_p^2 = .174$

Acute Protracted Error

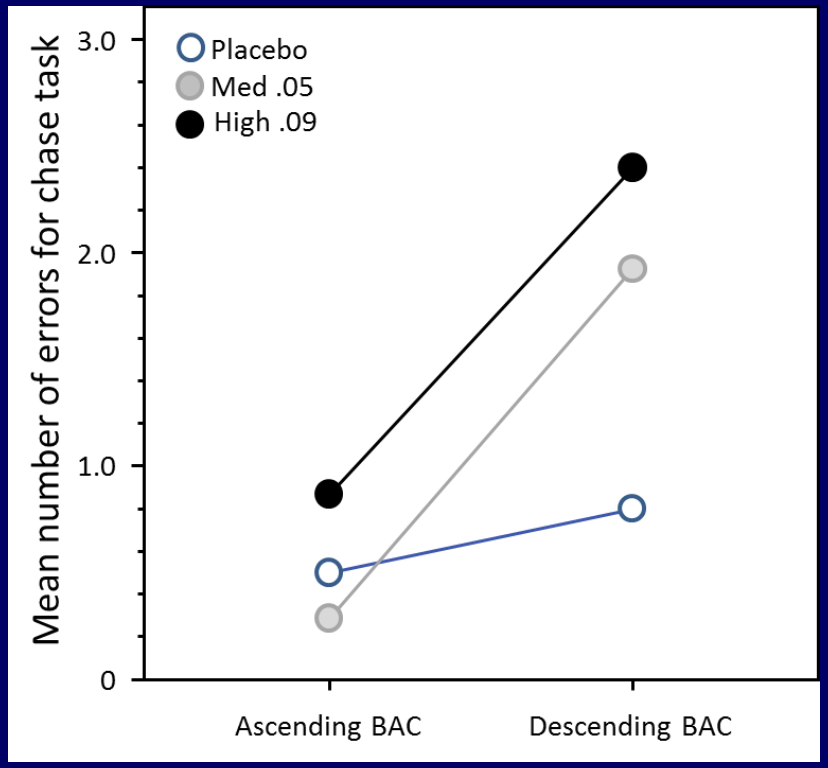
Chase task speed



Significant phase effect

$F(1,46) = 12.012$, $p = .001$, $\eta_p^2 = .207$

Chase task errors

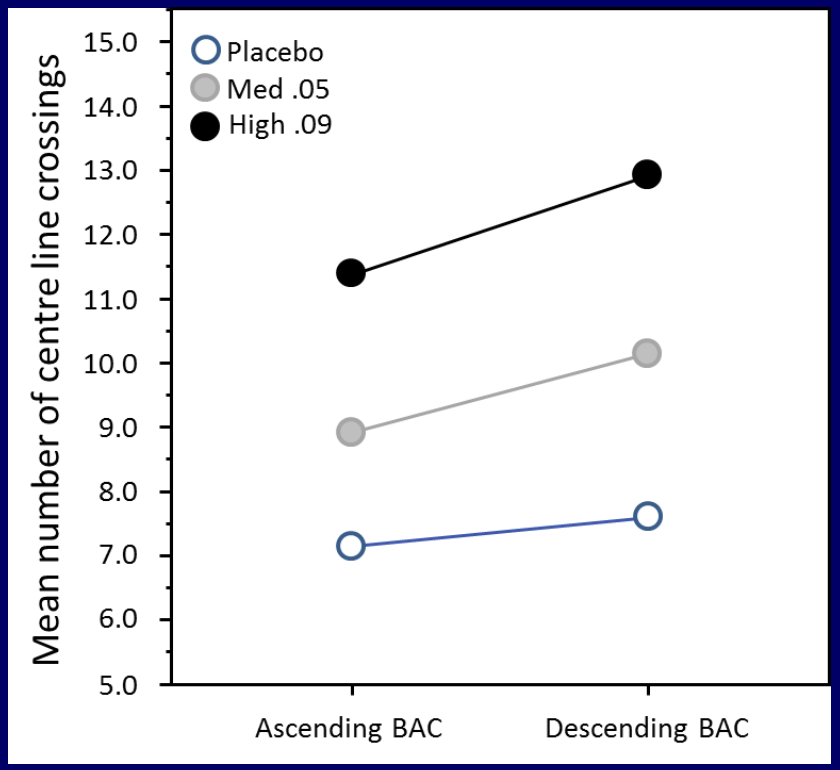


Significant phase effect

$F(1,46) = 10.437$, $p = .002$, $\eta_p^2 = .185$

Acute Protracted Error

Centre line crossings



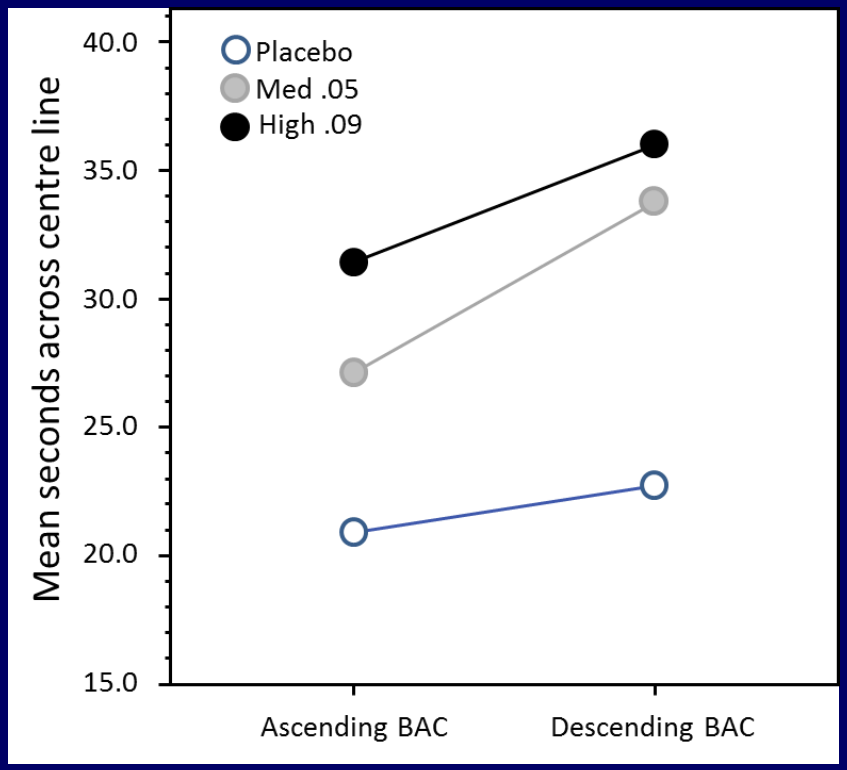
Significant phase effect

$F(1,45) = 3.827$, $p = .057$, $\eta_p^2 = .078$

Significant BAC effect

$F(2,45) = 13.193$, $p < .001$, $\eta_p^2 = .370$

Sec over the centre line



Significant phase effect

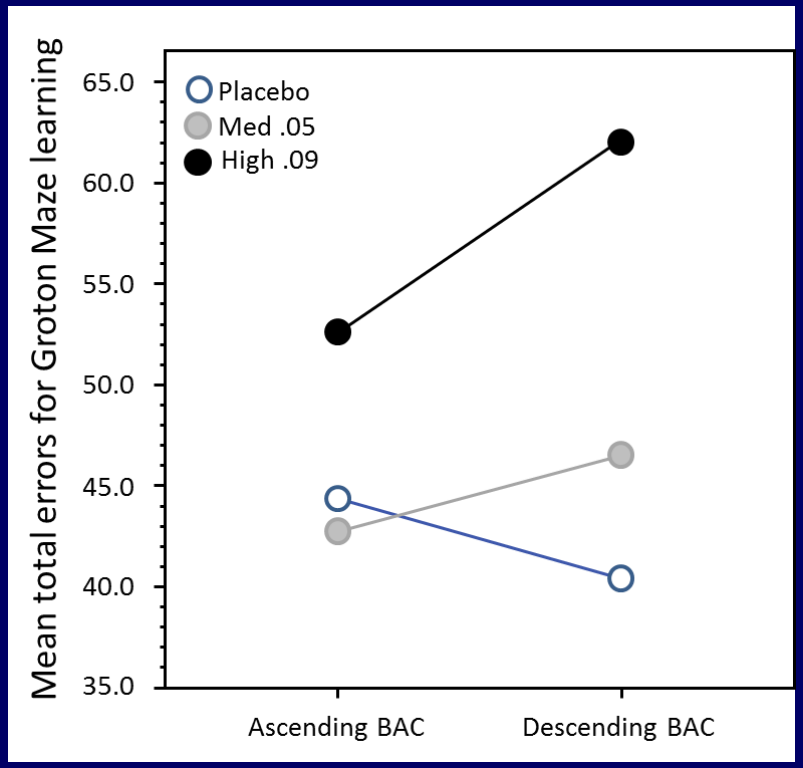
$F(1,45) = 6.888$, $p = .012$, $\eta_p^2 = .133$

Significant BAC effect

$F(2,45) = 10.067$, $p < .001$, $\eta_p^2 = .309$

Acute Protracted Error

Groton Maze learning errors



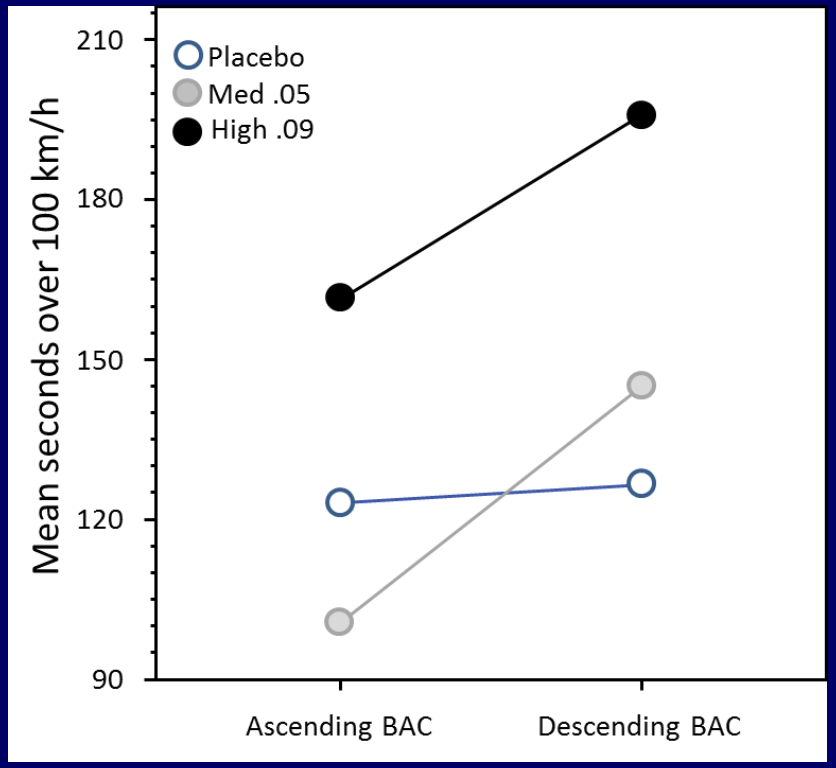
Significant BAC X phase interaction

$F(2,46) = 3.710$, $p = .032$, $\eta_p^2 = .139$

Significant BAC effect

$F(2,46) = 3.735$, $p = .031$, $\eta_p^2 = .140$

Sec over 100 km/h



Significant phase effect

$F(1,45) = 19.574$, $p < .001$, $\eta_p^2 < .303$

Significant BAC effect

$F(2,45) = 3.618$, $p < .035$, $\eta_p^2 = .139$

Significant BAC X phase interaction

$F(2,45) = 4.401$, $p = .018$, $\eta_p^2 = .164$

Summary of Findings

Participants were unable to judge how much alcohol they had consumed

Alcohol effects

.09 significantly worse than placebo on most measures

.05 significantly worse than placebo in reaction to hazard car (sec over the centre line)

.05 better than .09 for max speed and centre line crossings (otherwise not significantly different)

Acute tolerance effects

Subjective intoxication, willingness to drive and maze recall errors

Acute protracted error

Psychomotor speed and error (chase task), reactions to hazard cars (centre line crossings and sec) speed control (sec >100) and maze learning errors

Conclusions

Acute tolerance for self-ratings of intoxication and acute protracted errors for reactions to hazards, poor speed control and memory is a particularly dangerous mixture
(should be part of our current public education campaigns)

After drinking even moderate amounts of alcohol, drivers' judgement of their intoxication and consumption is impaired
(some drivers in the present study reported that they thought their driving had improved after drinking although it clearly had not)

Limitations

Alcohol intake in this study was clinically controlled
but not socially representative
need to examine role of habituation and social facilitation

Acknowledgements

Dr Nicola Starkey

Dr Paul Graham NZTA

NZTA Project TAR 11/17

All those who took part in this study and our research assistants and technicians who provided invaluable help

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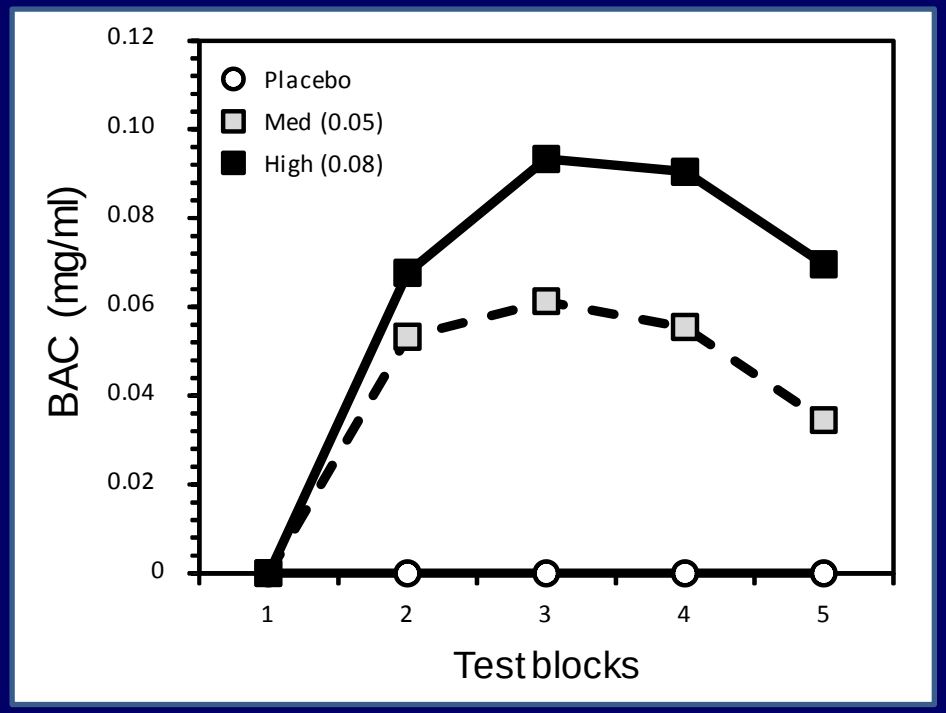
Results

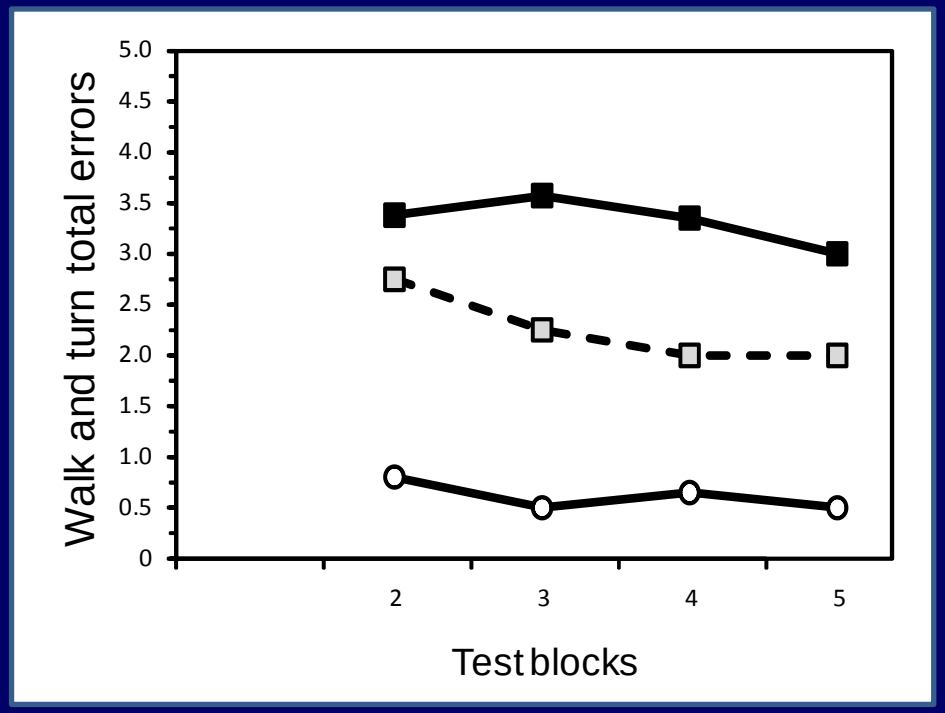
Effect on BAC



Significant group difference Blocks 2-5, p < .001

Post hoc pairwise comparisons (Bonferroni)
all groups significantly different, p < .001

Walk and Turn



Significant group difference Blocks 2-5, p < .001

Post hoc pairwise comparisons (Bonferroni)
Placebo lower than High at all blocks, p < .001
Placebo lower than Med at blocks 2-4, p < .05
Med and High not significantly different, p > .05