Institute for Transport Studies

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Vehicle safety technologies: the human behind the wheel

Samantha Jamson

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Overview

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- Case study approach (focus on one system)
- Allows a whole raft of issues to be covered
  - Acceptance
  - Driving as social process
  - Behavioural adaptation

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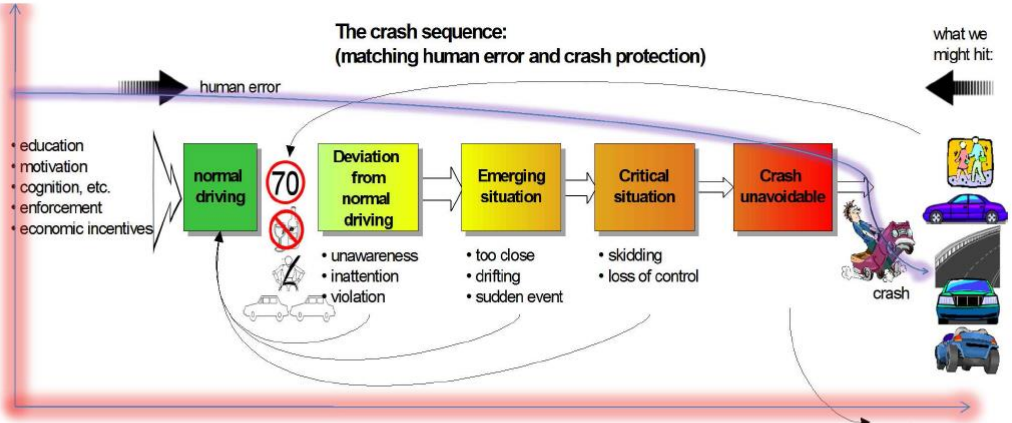
Vehicle safety technologies



• access to road transport system	• comfort • economy • social conformity	• warning system • supporting system	• intervention in driving	• immediate correction	• preparation for crash	crash protection
Vehicle	promote normal driving	(ISA, SBR, alcohol interlock)	(AICC, LDW)	(ESC, LDA, AICC2)	(pre-safe, emergency braking)	(seat belts, airbag, whiplash protection, pedestrian protection)
Infrastructure	promote normal driving	(speed warning, tactile warning, humps)	tactile edge lines	high friction surface		barrier design, roundabouts
Others	promote normal driving	• enforcement • insurance • contracts				• emergency service

Ref: Claus Tingvall (Swedish Transport Administration). The Safe System Approach

- Claes Tingvall argues that vehicle safety systems that keep drivers within the realms of “normal” driving tend to be the most effective (in terms of crash reduction)

Calculation of lives saved (Norway)

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Table S.1: Estimations of the number of lives saved according to selected driver support systems.

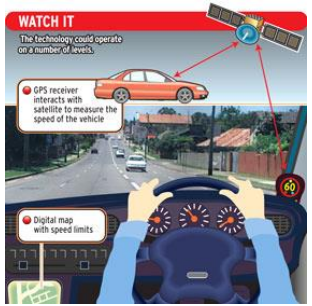
System Levels	Intell. Speed Adapt. (ISA)	Max. speed-governor	Alco-lock	Seat-belt lock	Warning of fatigue/sleeping at the wheel	Smart-card/ MyKey	Adaptive cruise control (ACC)	Electronic stability-control (ESC)
All/All drivers	41,0	8	34,0	29,1 *	100%: 29,8 50%: 14,9	(6,3) **	37,5	30,7
Young drivers 18-20 years of age	4,9	-	-	4,3 *	-	-	-	-
Young drivers 18-24 years of age	10,5	-	-	7,6 *	-	-	-	-
Prof. driving (method 1)	6,2	-	-	3.1	100%: 4,5 50%: 2,2	-	5,6	4,6
Prof. driving (method 2)	-	-	-	2,9	100%: 1,7 50%: 0,9	-	-	-
Drink drivers			4,6					
Speed violators	0,2	-						

Persons killed or seriously injured in road traffic accidents

	2013		Average last 5 years	
	Killed	Severely injured	Killed	Severely injured
Total	187	703	184	709
Males	135	443	137	468
Females	52	260	47	241
Group of road user				
Drivers of car	99	260	92	288
Passengers of car	31	113	34	147
Drivers and passengers on motorcycle and moped	24	129	23	115
Cyclists, pedestrians and persons sledging	28	190	31	147
Others	5	11	4	12
Age				
0-15 years	5	44	6	45
16-24 years	34	142	41	174
25-44 years	42	210	50	220
45-64 years	62	207	50	176
65 years or older	44	98	37	92
Unknown age	0	2	0	2

StatBank source table 09000

Ref: Vaa et al. 2014. Driver Support Systems. Estimating road safety effects at varying levels of implementation



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Acceptance – can't we just measure WTP*?

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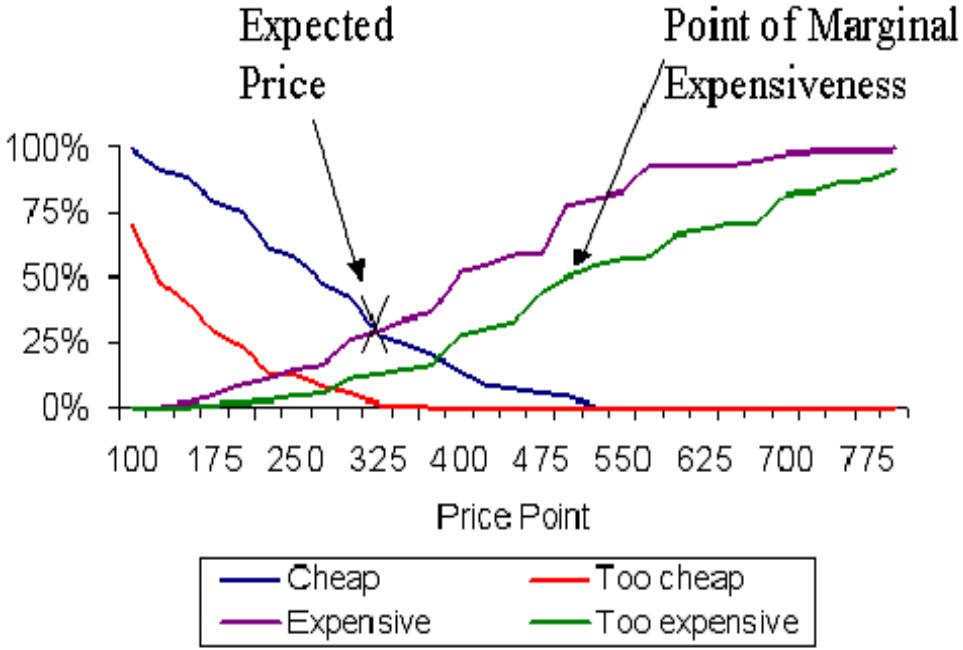
Don't we simply want to know if a driver would buy a system?

- At what price is the product so cheap that the product quality is questionable? Too cheap
- At what price is the product a bargain? **Cheap**
- At what price does the product begin to seem too expensive? **Expensive**
- At what price is the product too expensive to consider? Too Expensive



Ref: van Westendorp Procedure (price sensitivity)

**WTP= Willingness To Pay (buy)*

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Acceptance is multifaceted

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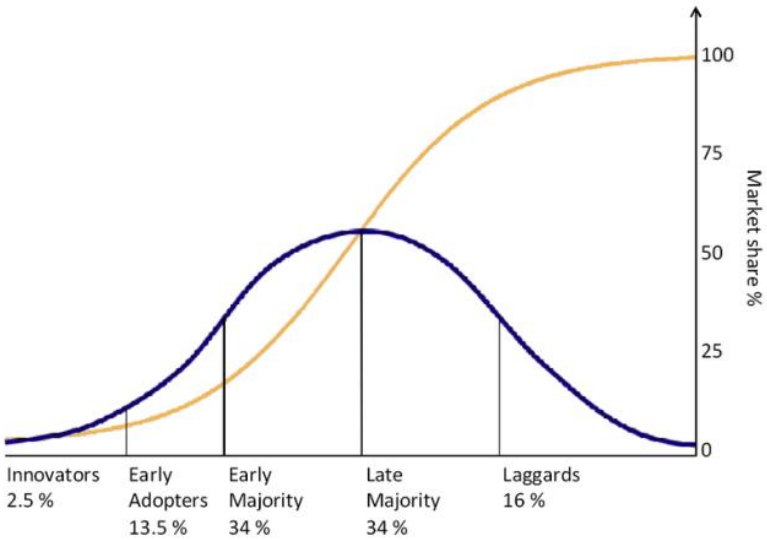
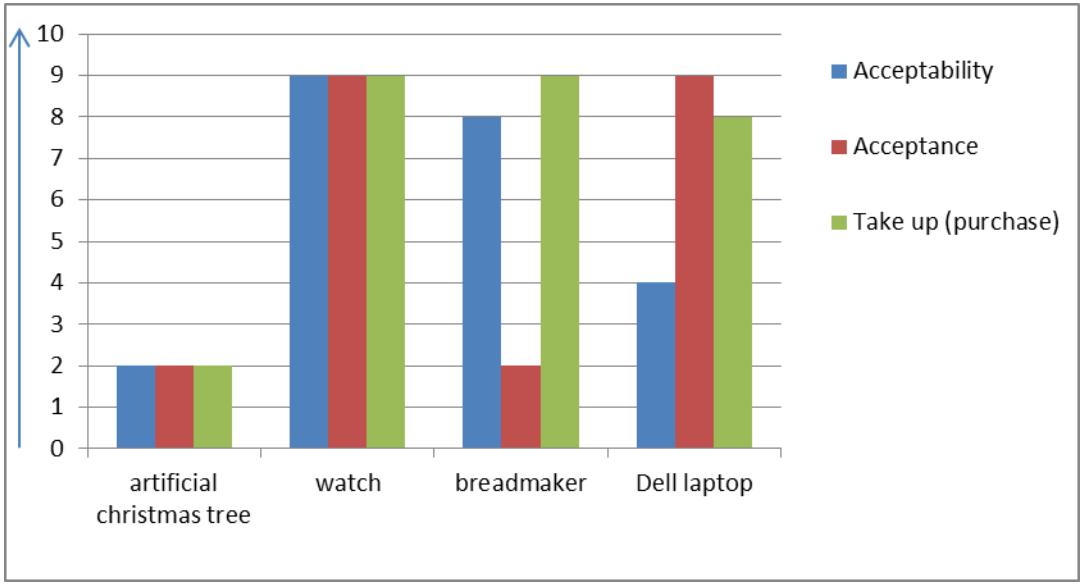


Ref: Rogers (1995) patterns of adoption



i. How much a systems is liked? Acceptability
ii. How much it would be used? Acceptance
iii. How likely someone would buy it? Take up (purchase)

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Vehicle safety systems -why try and predict acceptance?

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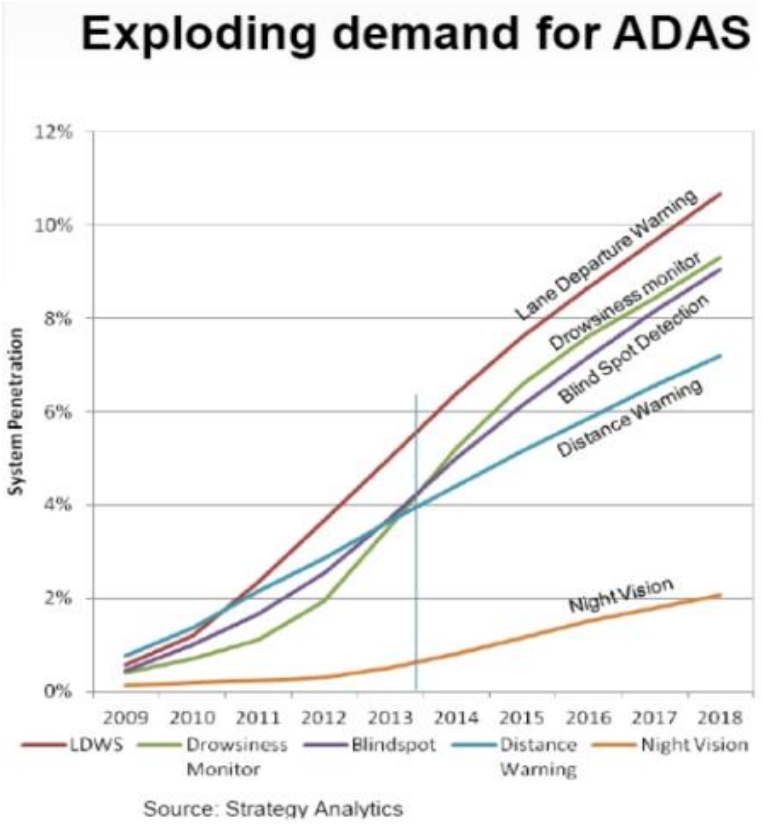
- Impact analyses (CBA) require information on take up and use.
- UK ISA project - linear increase in accident reduction with increasing penetration.

Penetration	ISA Variant		
	Advisory	Voluntary	Mandatory
20%	0.5%	2.4%	5.8%
40%	1.1%	4.8%	11.6%
60%	1.6%	7.2%	17.3%
80%	2.2%	9.6%	23.1%
100%	2.7%	12.0%	28.9%

Ref: Carsten & Tate (2005)

- But these penetration rates are hypothetical and depend, of course, on take up and use (use- for a voluntary system)



It is never that easy – survival of the safest!

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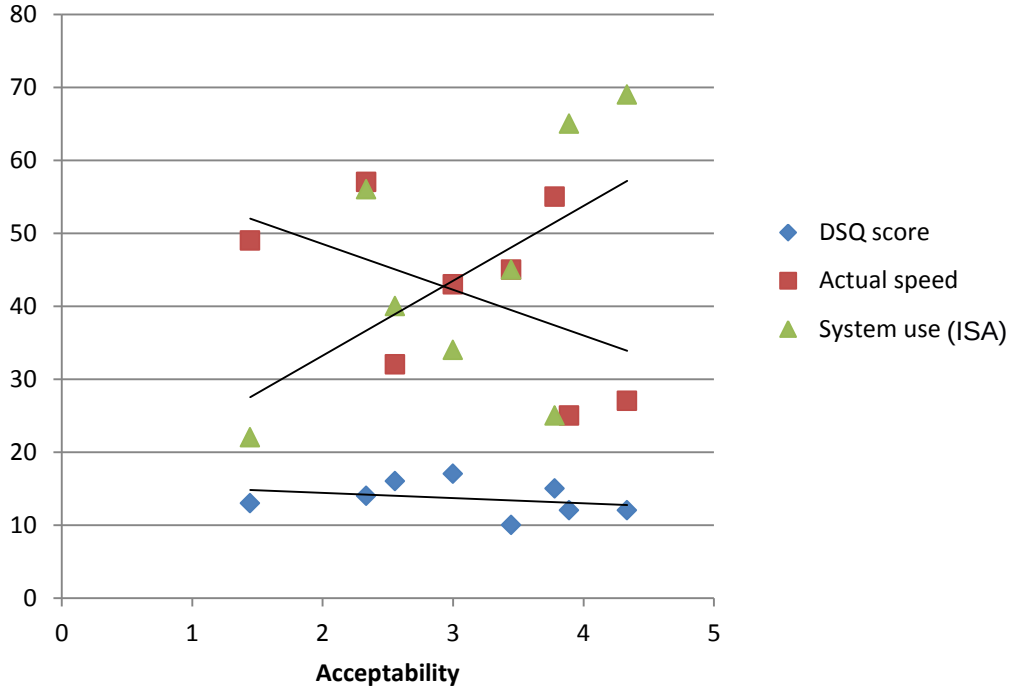
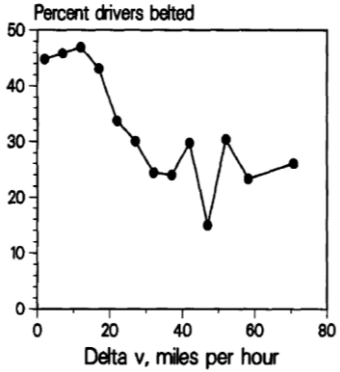


Those who need ISA, don't use it

- Such "selective recruitment" was termed by Evans in his analysis of seat belt and non-seatbelt wearing fatalities.
- He demonstrated that the probability that a driver was wearing a seat belt at the time of the crash declined as crash severity increased.
- In other words, drivers who would benefit most are those least likely to wear a seat-belt



(Ref: Evans, 1996)

Drivers and their passengers

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Early studies (1940s-1980s)

- Showed a positive influence of passengers
- Speed was lower and headways longer when passengers present
- Thought to be a consequence of reduced attention available, such that drivers increased their safety margins to compensate
- Epidemiological and behavioural studies followed
- A more complex picture was revealed

	One passenger	Two passengers	Three passengers
16-year-old driver	1.39 (95% CI 1.24–1.55)	1.86 (95% CI 1.56–2.20)	2.82 (95% CI 2.27–3.50)
17-year-old driver	1.48 (95% CI 1.35–1.62)	2.58 (95% CI 2.24–2.95)	3.07 (95% CI 2.50–3.77)

More recent studies (1990s →)

- Driver age
- Driver gender
- Relative to the passenger age/gender
- Younger driver crash risk ↑ when carrying peers
  but ↓ if an adult or a child
- Male passengers have a stronger effect (more unsafe) compared to female passengers

Carrying at least three passengers results in a threefold increase in the probability of suffering a fatal injury

(Ref: Chen et al, 2000)

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Driving as a social (cognitive/visual) process

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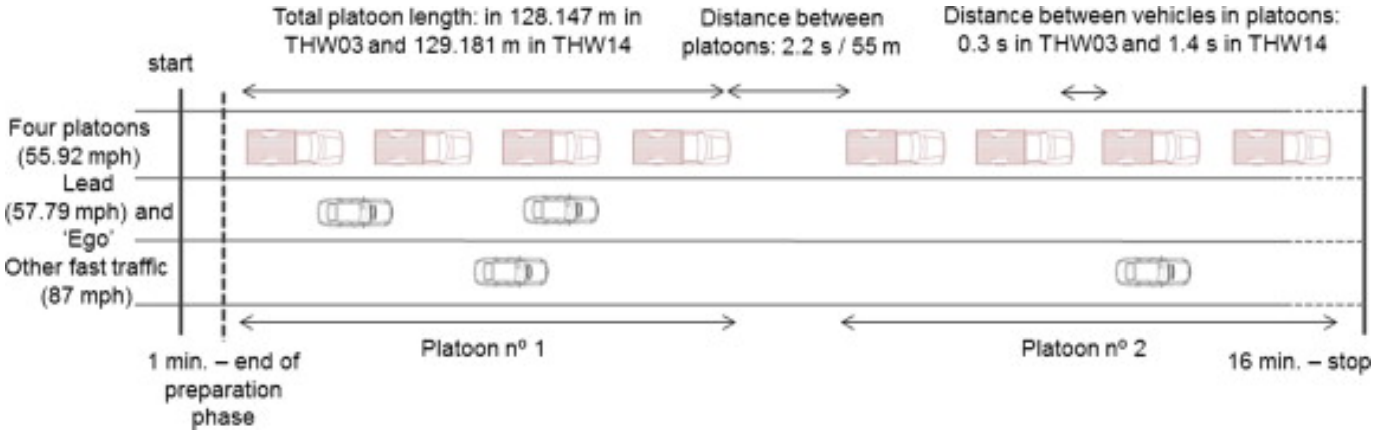
- Unequipped drivers drove next to automated vehicle platoons.



- They adapted their driving behaviour by displaying a significant shorter average and minimum THW.

UK ISA study: drivers were concerned about being the "*only driver travelling at the speed limit*"

Ref: Gouy et al. 2014. Driving next to automated vehicle platoons

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Behavioural adaptation

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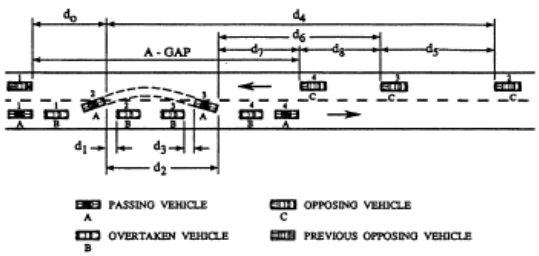
- *"ISA could make overtaking difficult, and prevent accelerating out of a misjudged situation in some cases"* (unfounded)
- Overtaking is a complex the driver needs to:
  - monitor their interaction with a lead vehicle
  - estimate the TTC of any oncoming vehicles
  - Calculate time needed to complete the overtake
- What happens when you disrupt this task?



Stages of the passing process:
1 - Before passing ; 2 - Start of passing ; 3 - End of passing ; 4 - Meeting oncoming vehicle

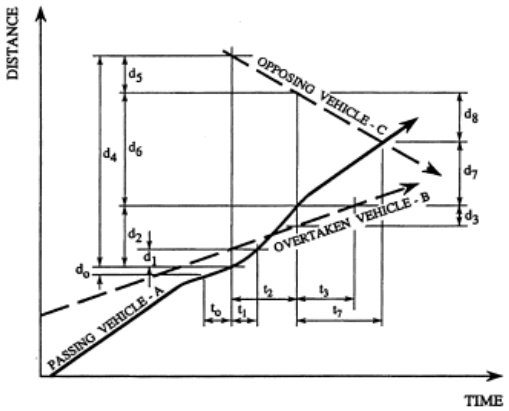


FIGURE 1 Stages and elements of the passing maneuver and time-distance graph of vehicle trajectories in the passing maneuver.

Ref: Polis et al 2007

Behavioural adaptation to ISA

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- Thus with ISA, we were interested to discover <u>if</u> behavioural adaptation did occur and <u>how</u> it was manifested
  - Propensity to overtake
  - Abandoned overtakings
  - Erroneous overtakings
- Drivers used mandatory and voluntary ISA.
- Voluntary ISA allowed “opt-out”

Evidence of behavioural adaptation?

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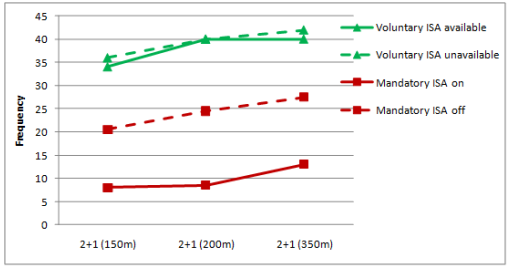
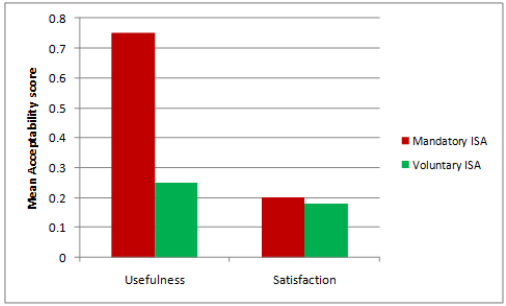
- Where possible, i.e. with voluntary ISA, drivers chose not to adapt their overtaking behaviour (they opted out in 70% of the overtaking scenarios)
- With mandatory ISA, drivers were less likely to engage in overtaking
  - But when they did, their strategy was to complete the manoeuvre as quickly as possible
  - This sometimes failed and the overtaking led to encroachments and abandonments





Behavioural adaptation and vehicle safety

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Behavioural adaptation is more likely when drivers attend to a change than when they do not:

- No change in driver behaviour with air bags
- Less safe behaviour with antilock brakes (ABS) (Sagberg, Fosser, & Sætermo, 1997)
- Effect more pronounced when drivers experience effects of ABS first hand (Grant & Smiley, 1993)

- Have we come full circle: to limit BA, vehicle safety systems need to be supportive, in a silent way – and not depart too much from normal driving?

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