Interactions involving autonomous vehicles in the urban street environment: a research agenda

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Outline

1. What are Autonomous vehicles and why are we so interested in them?
2. The Venturer project
3. Matching Avs to roads: use scenarios
4. Interactions in the street environment
5. Research Questions
6. Wider acceptance of autonomous vehicles: results of a pilot

1 What and why?




Car

Taxi

Shared taxi

Bus

Lorries …and so on …or ‘pods’

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

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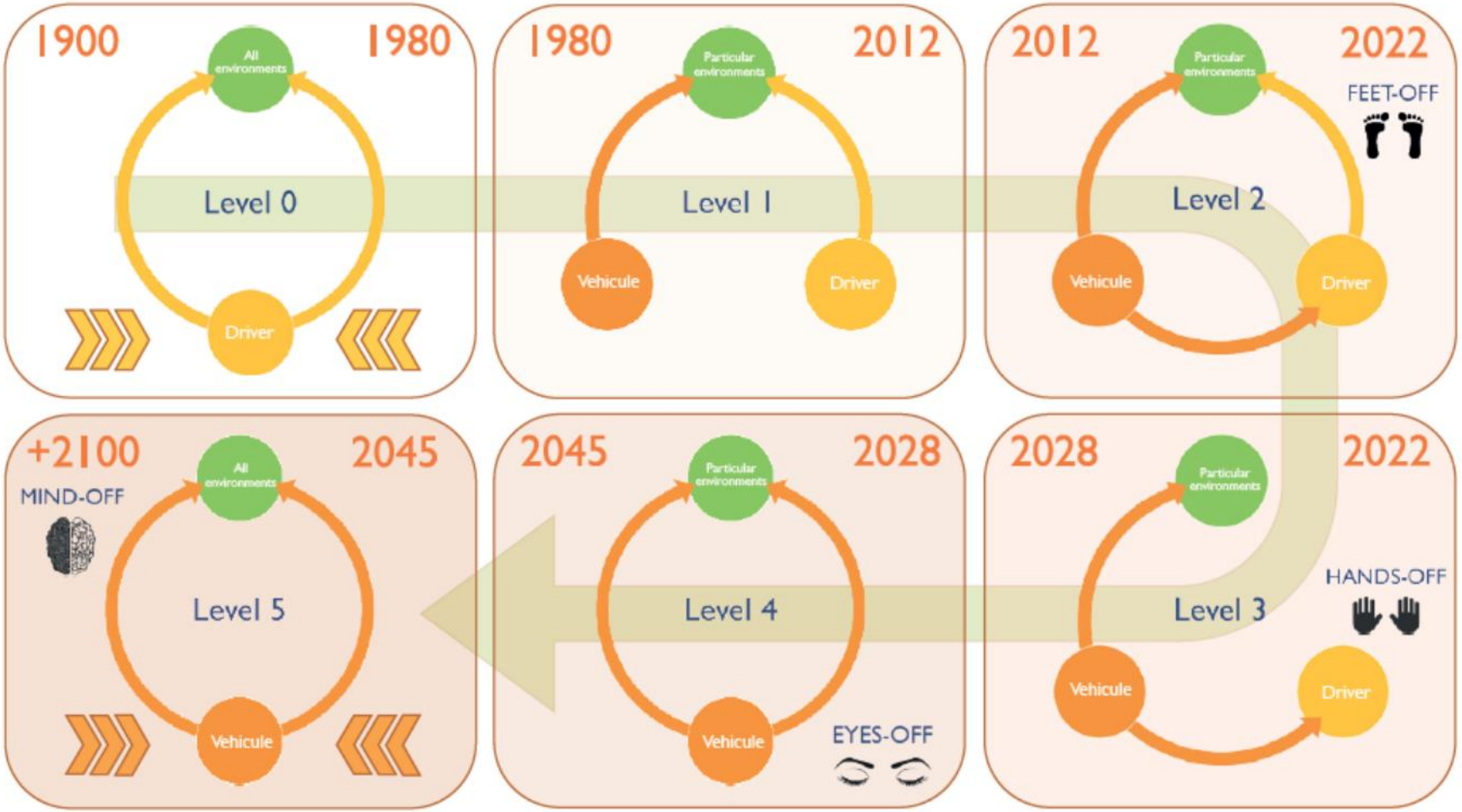
Timescales?



(Yole Développement, October 2015)

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The critical Level 3

Google car: trials with a safety driver

Volvo:

- Follow lanes
- Follow cars
- Adapt speed
- Merge
- 'fail safe'.

Tesla:

- Auto steer
- Auto lane change
- Automatic emergency steering
- Emergency collision warning
- Side collision warning
- Auto park

Tesla: on the open market

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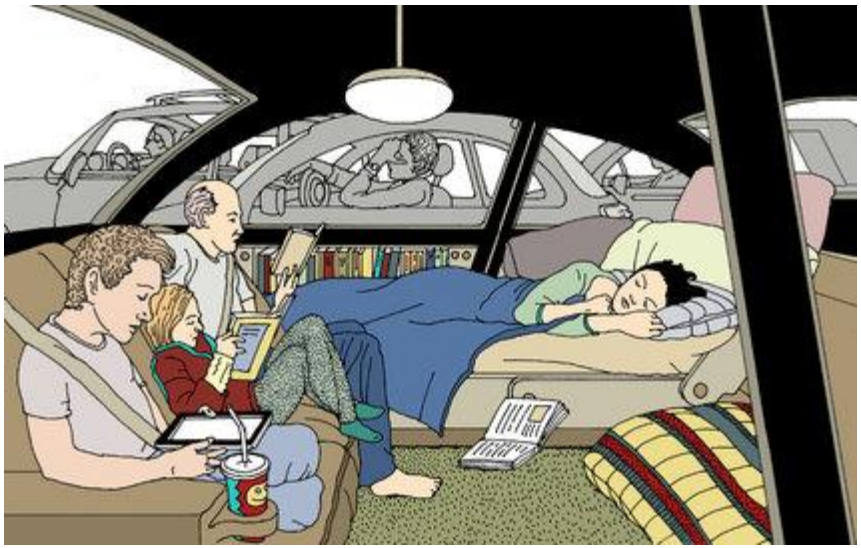
New social practices?

- Level 3
  - Machine-readable environments?



- Level 4
  - the ‘sleeper car’

- Level 5
  - AV-chauffeuring?

Department for Transport

The Pathway to Driverless Cars:
A Code of Practice for testing

Moving Britain Ahead

"The UK government recognises the potential benefits of driverless and automated vehicle technologies, particularly the potential to improve road safety and reduce casualties."

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Improving the **efficiency** with which we use our **road network**

The average driver in England can save up to **6 working weeks** a year driving time

Fewer deaths and injuries

Money saving through **reduced** insurance costs

Opens up access to cars for **everyone** increasing social inclusion

31% **women** do not hold a full driving licence

14% **men** do not hold a full driving licence

46% **17-30 year olds** do not hold a full driving licence

Reduce pollution

Department for Transport

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2 The Venturer Project

BAE SYSTEMS
INSPIRED WORK

ATKINS

AXA

WILLIAMS

BURGES SALMON

Fusion Processing

First

University of BRISTOL

brl

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BRISTOL CITY COUNCIL

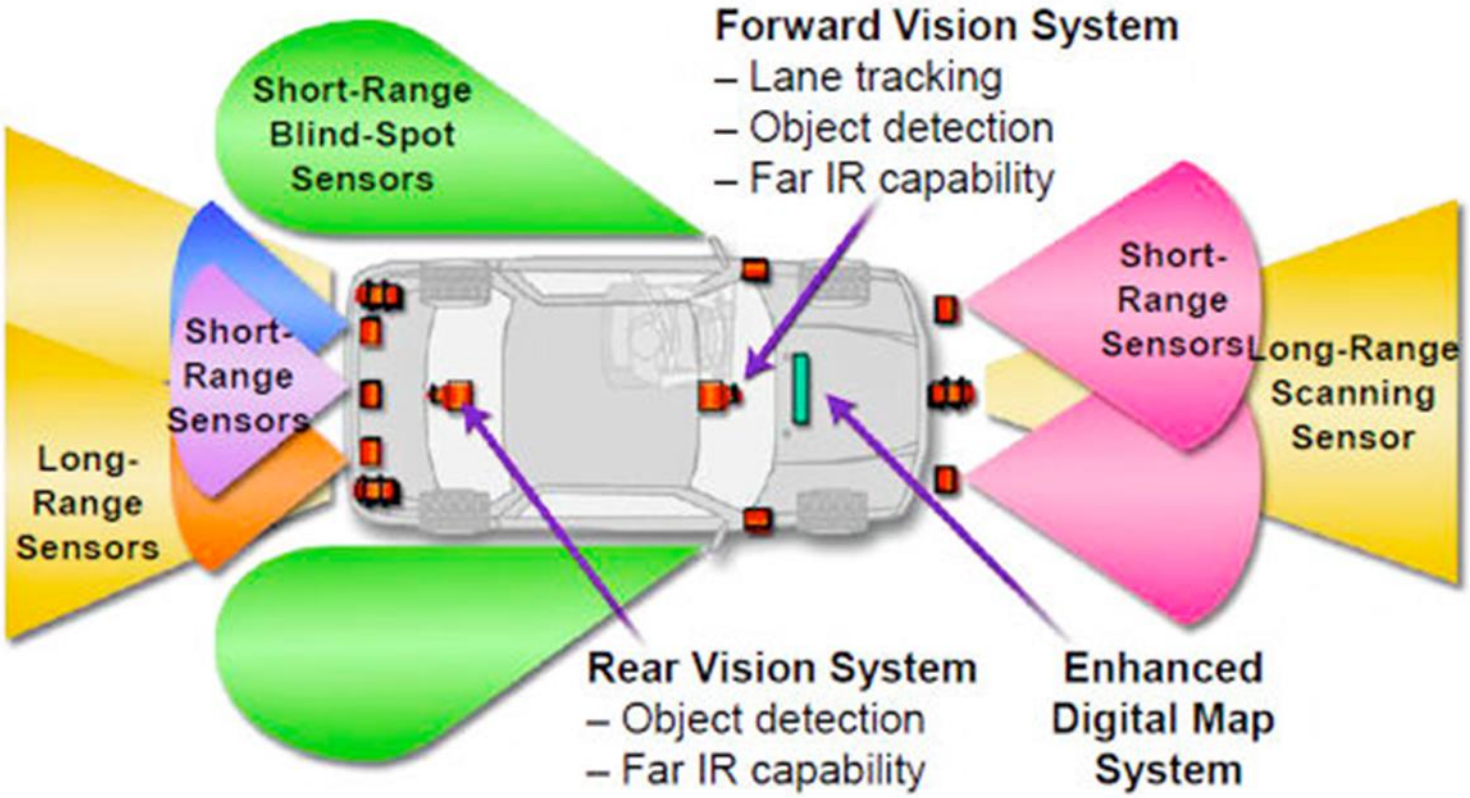
VENTURER

South Gloucestershire Council

Driverless Cars on UK Roads

http://www.venturer-cars.com/

The vehicle


Forward Vision System
– Lane tracking
– Object detection
– Far IR capability
Short-Range Blind-Spot Sensors
Short-Range Sensors
Long-Range Sensors
Short-Range Sensors
Long-Range Scanning Sensor
Rear Vision System
– Object detection
– Far IR capability
Enhanced Digital Map System

3 Use scenarios

US1 Fully segregated AV network

- Completely segregated
- Have their own system
- Interact only with other AVs

West Virginia University, Morgantown, 1973

Heathrow Terminal 5, 2011

US2 Motorways and expressways

- Mixed with driven vehicles
- Only motor traffic present
- Only on high-volume, high-speed
- Infrastructure highly engineered
- Significant instrumentation and management

Truck platooning trial, converging on Rotterdam, 2016

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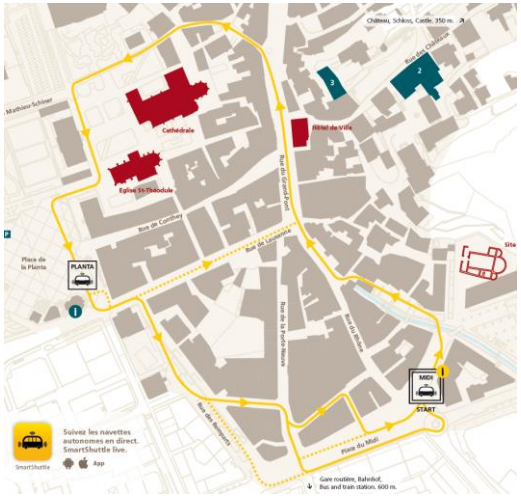
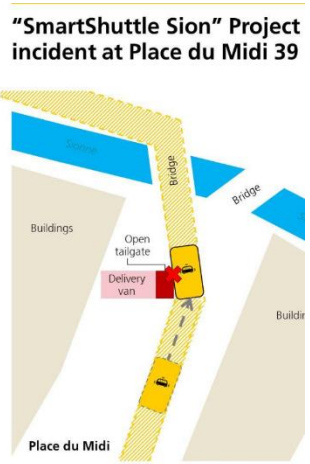
US3 Typical urban network

- Arterial roads, distributor roads, high streets, access roads and local streets
- Range of road user types
- Complex highly variable infrastructure
- Variety of junction types, layouts and control
- Frequent changes in numbers of lanes available
- Great variety in level and type of management (regulation)
- Place as well as movement function

US4 Shared space

- Carefully designed to reduce traffic speeds
- Often entails removing physical features and street furniture
- Less well defined and regulated than a typical urban road
- Interact on equal basis with no priority





PostAuto trials, Sion, Switzerland, 2016,
https://www.postauto.ch/en/smartshuttle-projekt

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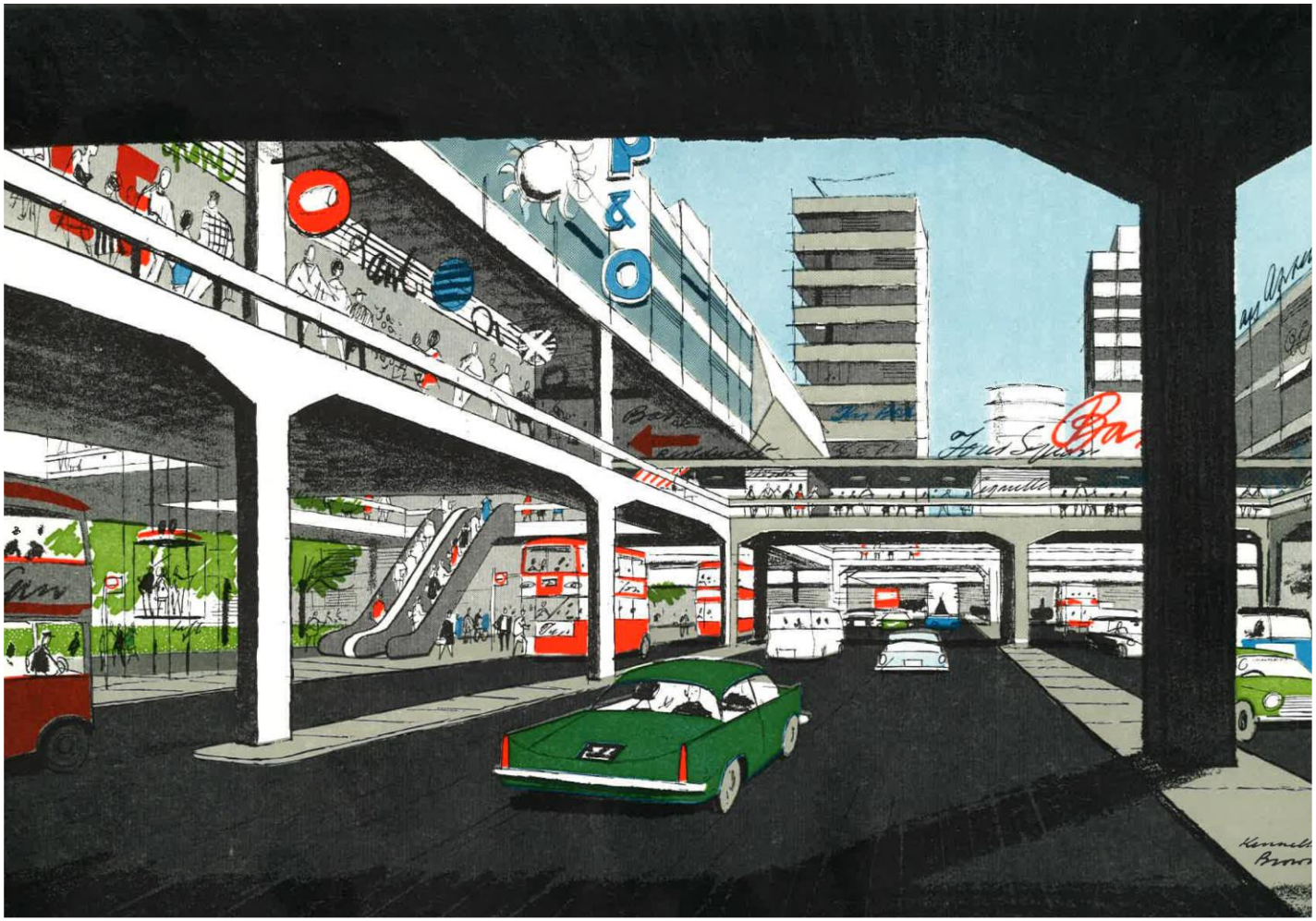
Design sprints to the future

Skinner, R. and Bidwell, N. (2016) Making better places: Autonomous vehicles and future opportunities. WSPPB and Farrells. Available at: http://www.wsp-pb.com/Globaln/UK/WSPPB-Farrells-AV-whitepaper.pdf

Fifty years on…



4 Interactions in the street environment

- Private car is a deeply ingrained cultural icon (Thrift, 2004)
- Driving is not done in a social vacuum (Wilde, 1976)
- "The car is all too capable of undermining its own utility" (Shaw and Docherty, 2013, p12)
- There is a social layer of rules, customs, and bespoke modes of communication

Issues:

- Road users may not behave in a sufficiently patterned way for machine

Rule 110

- **Flashing headlights.** Only flash your headlights to let other road users know that you are there. Do not flash your headlights to convey any other message or intimidate other road users.

ghts)

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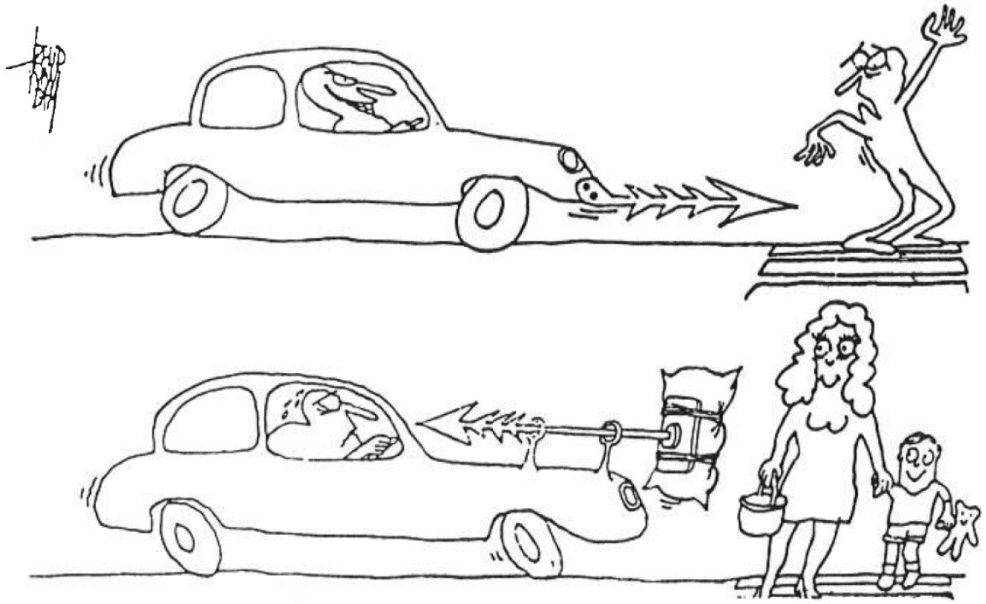
Aggressive behaviour

When the emotional supervenes the rational

- Aggressive driving: dangerous or forceful manoeuvring, no intention to harm
- Road rage: action specifically to harm (Schafer, 2015).



Source: Davis, R. (1992) Death on the streets. Leading edge Press, Hawes. From a Dutch cartoon

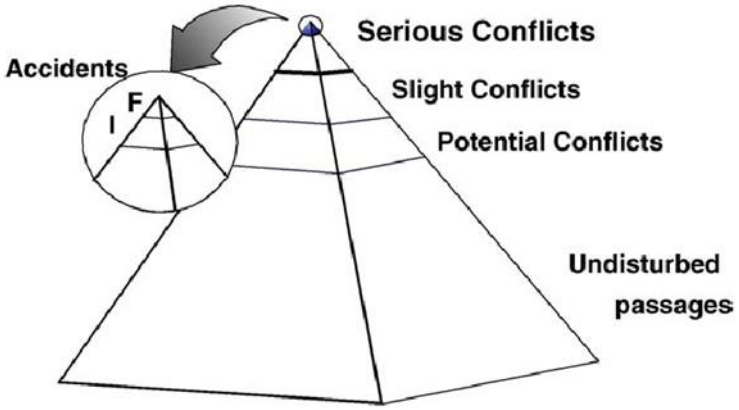
Collisions and conflicts

Conflict: 'two or more road users approach each other in time and space to such an extent that a collision is imminent if their movements remain unchanged'.

Collision: unresolved conflict

Challenges:

- Majority of knowledge is about collisions
- Majority of conflicts go unobserved
- Conflicts are however, critical from the point of view of user experience



Top five contributory factors:

- *Driver/Rider failed to look properly, 46%;*
- *Driver/Rider failed to accurately judge other person's path or speed, 24%;*
- *Driver/Rider careless, reckless or in a hurry, 18%;*
- *Poor turn or manoeuvre, 16%;*
- *Loss of control, 13%.*

Is this a dagger which I see before me, the handle toward my hand?

'Should driverless cars kill their own passengers to save a pedestrian?' Goldhill (2015)

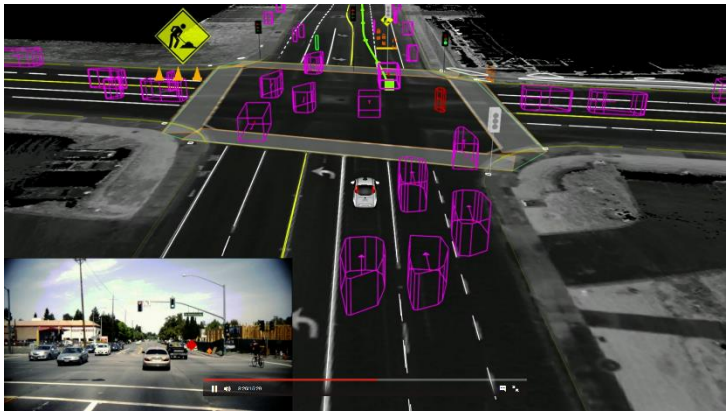
- **Utilitarianism / moral obligation**: 'maximises happiness', therefore minimise loss of life
- **Incommensurability / participation in a moral wrong**: AVs programmed to save those outside vehicle, and AV users should know the risks

Bonnefon et al. (2015):

- 75% say do not kill pedestrians
- Effect dramatically weakened if they were in the car

Adams (2015)

- 'Deferential' programming = AVs 'going nowhere'



5 Research Questions

General philosophy

- What should the main sources of influence be in shaping the philosophy of transport and urban planning and management in response to AV technology?
- How should AVs be programmed to take action in the event of conflict that could lead to collision?
- How will machine learning and human learning co-evolve?
- How will AV predictability and its effect on traffic flow change driver behaviour?
- How will AVs manage antagonistic or aggressive driver behaviour?

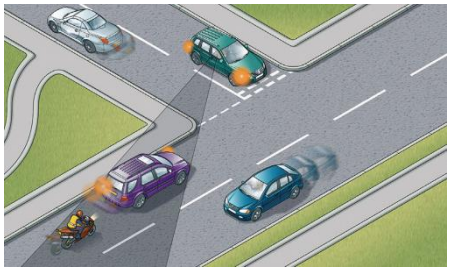
Cyclists and pedestrians

- How will AVs change perceptions of hazard posed by motorised traffic to cycle users?
- Will severance for pedestrians be reduced?
- How do AVs affect pedestrian behaviour in shared space?

Changes

- What change to regulations may be required?
- How will the Highway Code need to change?

Venturer trials

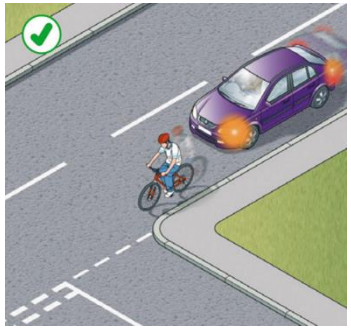


Gap acceptance of car turning out of side road in presence of AV

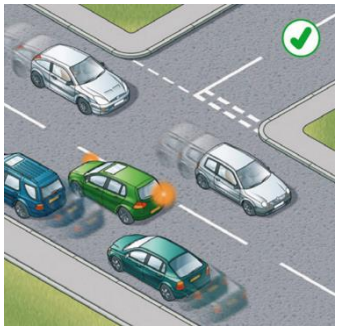
Gap acceptance of bicycle turning out of side road in presence of AV

Gap acceptance of pedestrian crossing road (Rule 7)

AV behaviour turning left with pedestrian crossing side road (Rule 170)



AV behaviour turning left with cyclist going straight on (Rule 182)



AV behaviour and cyclist gap acceptance turning right into side road (Rule 180)

Passing distance to bicycle (Rule 163)

6 Acceptance

Willingness to pay

How much will they be willing to pay?

Pilot survey amongst transport professionals

N=100 (79 car drivers)

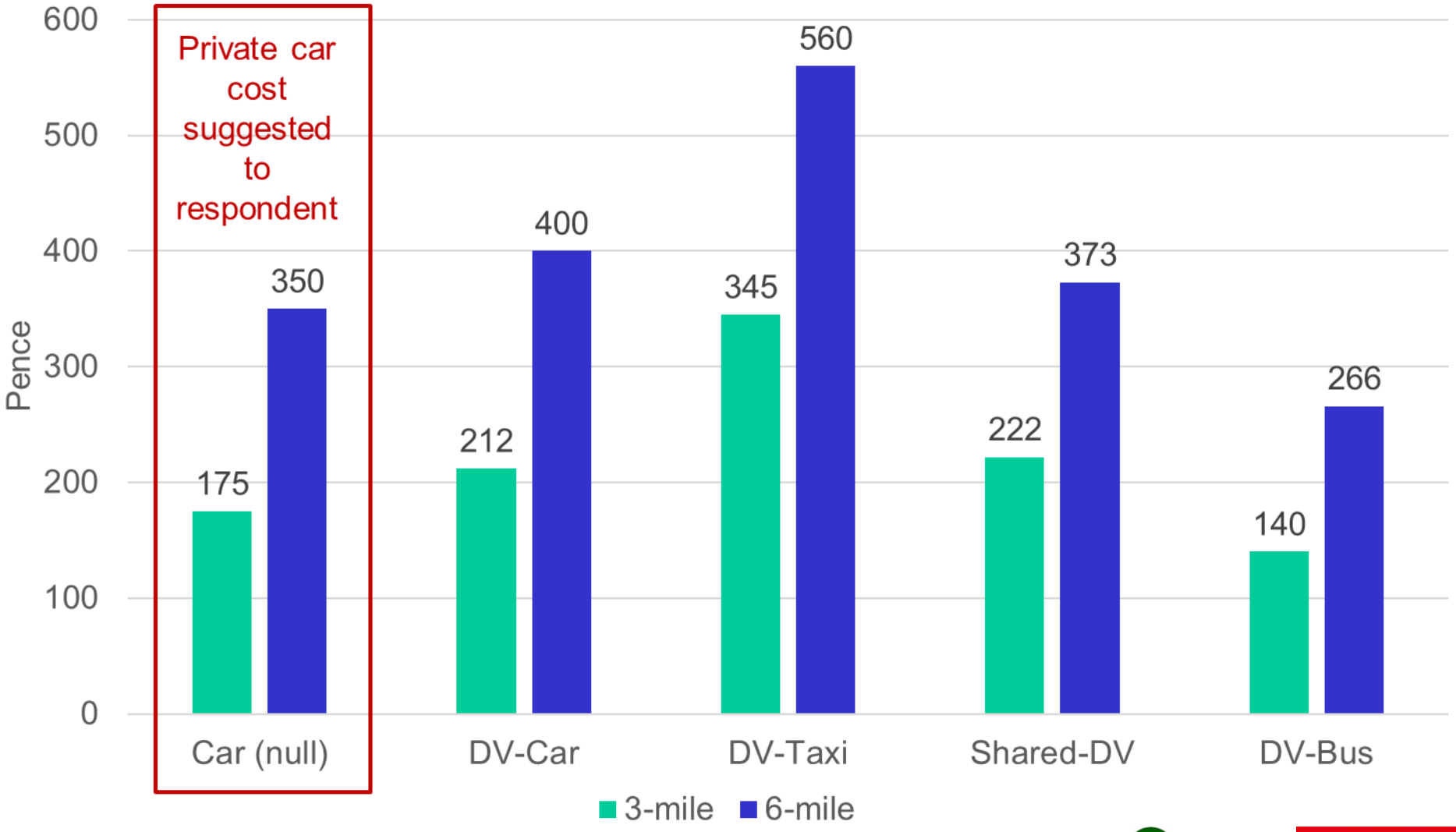
AV-Car

AV-Taxi

AV-Shared taxi

AV-Bus

Car users willingness to pay



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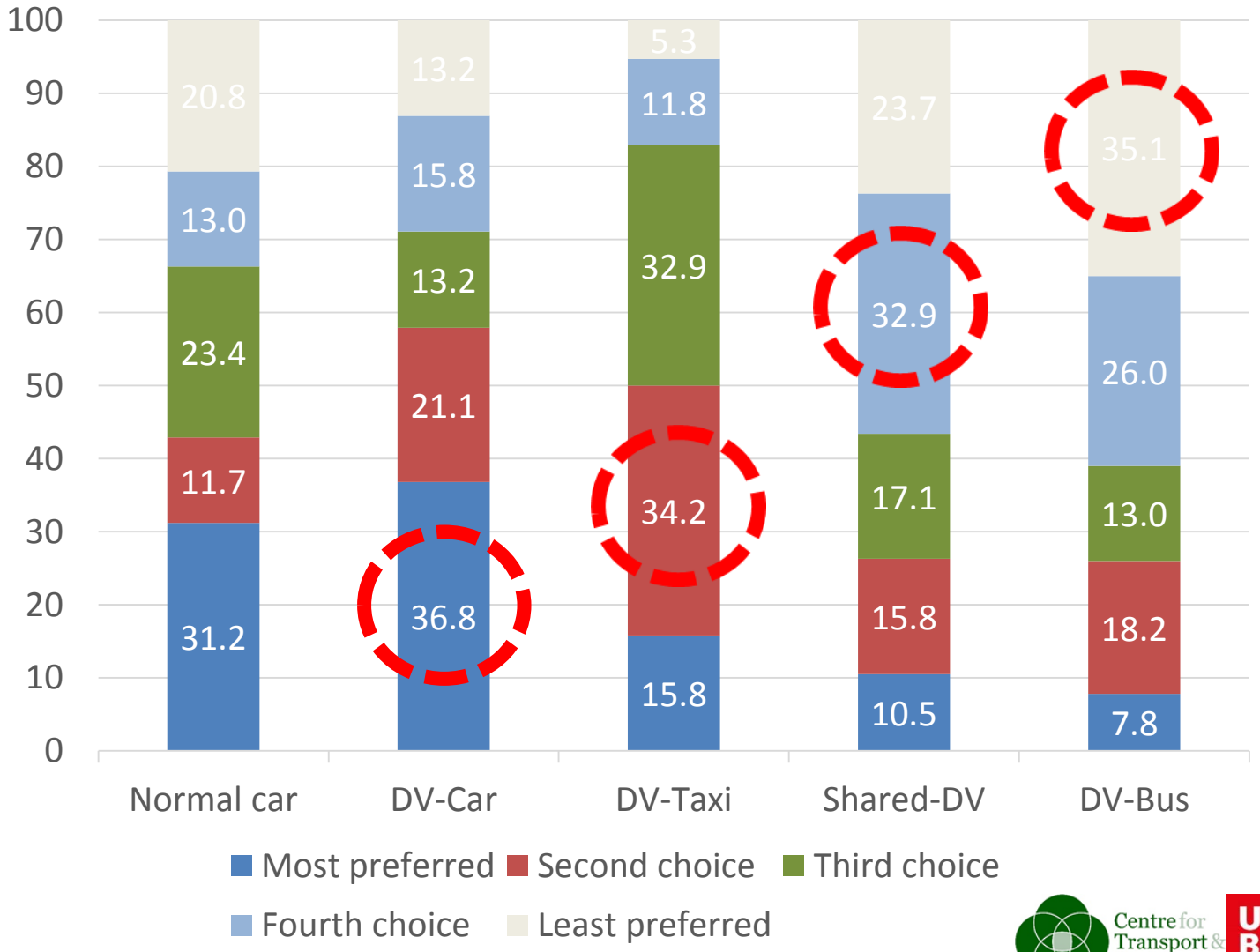
Car users: some conjectures

Mode	Car	Taxi	Shared Taxi	Bus
Human-driven cost (£/km)	£0.58	£2.23	?	£0.42
AV W2P (£/km)	£0.67	£0.93	£ 0.62	£0.44
AV cost (say 50% of human-driven costs, £/km)	-	£1.12	?	£ 0.21
W2P / cost	+116%	83%	?	210%
Conclusion	Willing to pay technology premium	More affordable than now	Possible?	Possible?

Car users ranking of choice



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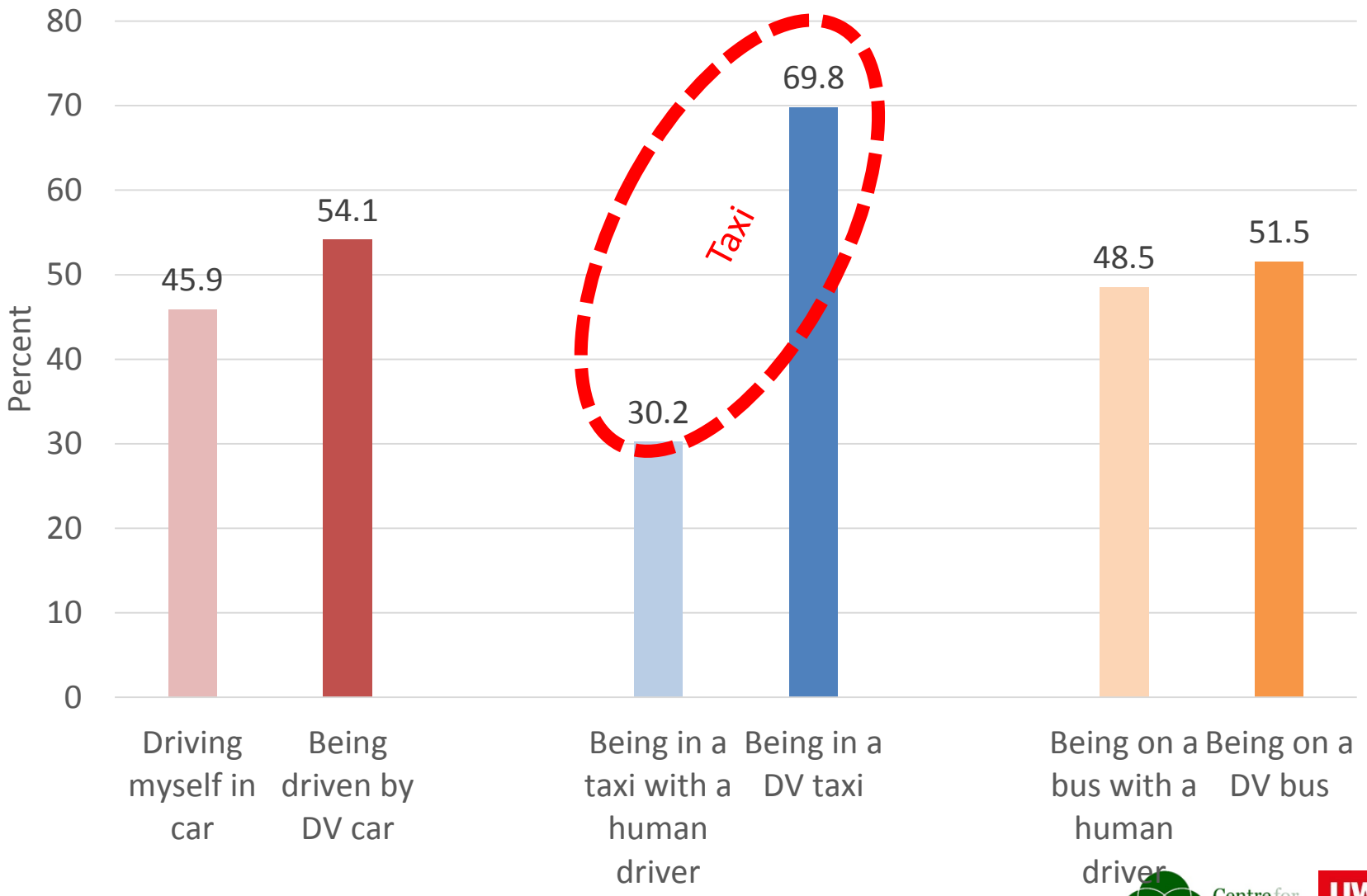
Preferences



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