Evaluation of Acceptance, Safety and Trust of Advanced Driver Assistance Systems with Respect to Influences of Age, Gender and Road Conditions

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Accident Statistics

Bei Verkehrsunfällen werden weltweit jährlich 50 Mio. Menschen verletzt und 1.2 Mio. Menschen getötet (WHO, 2015)

In the USA adverse weather:

- Contributing factor in more than 1.5 million vehicular crashes annually
- 28% of total accidents, and
- Almost 20% of highway fatalities

(NRC, 2004; Eisenberg & Warner, 2005; American Meteorological Society, 2004)

Fahrzeugautomatisierung

Anzahl der Verkehrsunfälle durch Fahrzeugautomatisierung reduzieren (European Commission, 2011; WHO, 2015)

Herausforderung:

Entwicklung von Fahrstrategien, die eine dynamische Interaktion mit anderen Verkehrsteilnehmern und Umwelteinflüsse berücksichtigen (European Road Transport Research Advisory Council, 2015)

Research question

Are there any significant differences in the **assessment** of longitudinal vehicle control of Advanced Driver Assistance Systems in normal and critical driving situations depending on

- **gender**,
- **age** and
- **road conditions**?

Snow

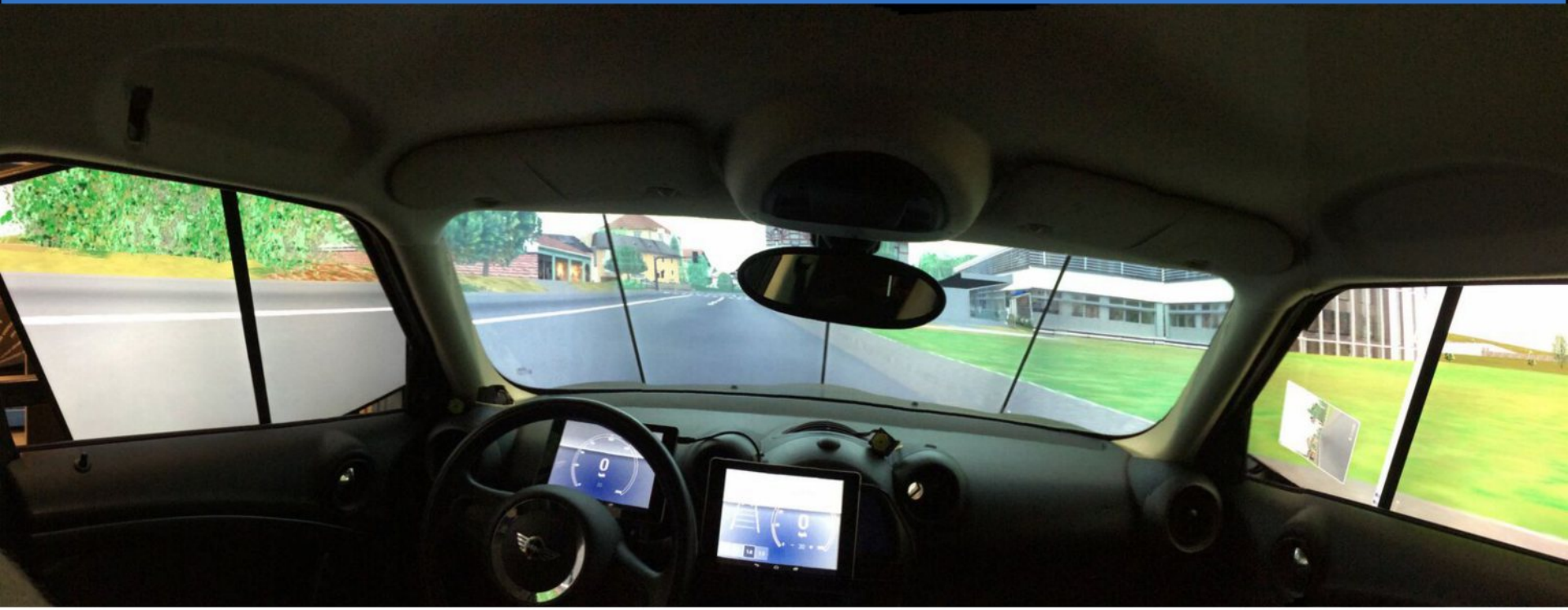
Research project MueGen Driving

Funding program: BMVIT, FFG FEMtech Talente (FFG No. 3413253)

Consortium:

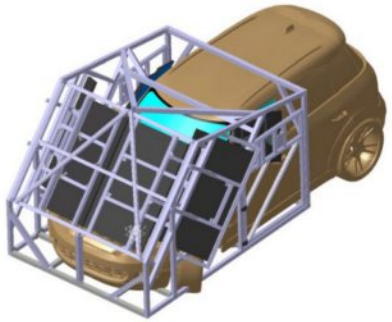
- Institute of Automotive Engineering (TU Graz)
- Fraunhofer Austria Research GmbH
- AVL List GmbH
- SBW Technology LTD

ADSG
Automated Driving Simulator Graz



Automated Driving Simulator Graz (ADSG)

- Full vehicle (Mini Countryman)
- Autostereoscopic Visualisation (Fraunhofer Austria)
- Detailed acoustic simulation (AVL)
- Force-Feedback (SBW Technology, TU Graz-FTG)
- Integrated Eye Tracking (Smarteye)
- Configurable Human-Machine-Interfaces (TU Graz-FTG)
- Integrated Automated Driving (TU Graz-FTG)
- Configurable traffic or co-simulation with microscopic traffic simulation (TU Graz-ISV)
- Driving environment according to project (Fraunhofer Austria)
- Motion platform in preparation



Der Abstandsregeltempomat (ACC)

Regelt eine **voreingestellte Geschwindigkeit**

erkennt langsamer vorausfahrende Fahrzeuge, reduziert die Geschwindigkeit und folgt diesen mit einem von Fahrer/-in **voreingestelltem Abstand (z.B.**

1 Sek., 1.8 Sek.)

Autofahrer/ -innen müssen bei Systemausfall die **Kontrolle übernehmen**

ACC hat keine Information über den **Fahrbahnzustand**

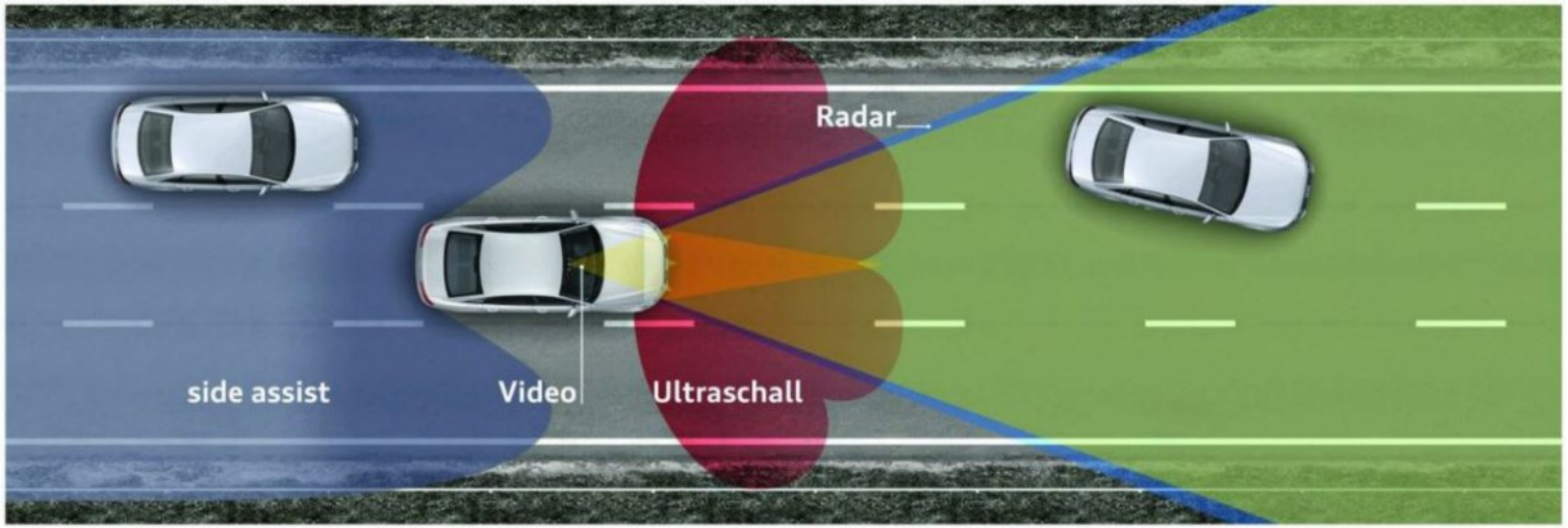


Abbildung von A. Vukotich, G. Duba, and T. Gollewski. Fahrerassistenzsysteme. ATZextra, 15(11):S. 178{180, 2010

Driving Simulator Study

Participants

- 96 drivers, (48 women, 48 men)
- Age 20-75 years (5 age groups 20-29, 30-39, 40-49, 50-59, 60+)
- Driving activity (M = 18.208, SD = 10.802 km/year)

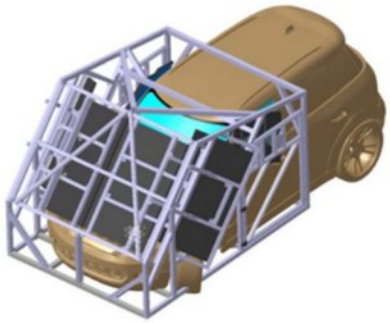
Experimental variables

ACC set speed 100-130 km/h selected by the drivers

ACC gap: 1 vs. 1.8 Seconds

Variation of the tire-road grip (dry μ=1, snowy μ=0.5)

Selected test maneuvers (relevant for ACC)



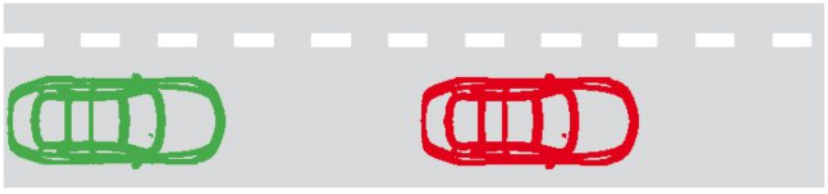
Selected driving maneuvers ACC (highway)

1) Approaching slower target vehicle

ACC set speed:
100-130 km/h

80 km/h

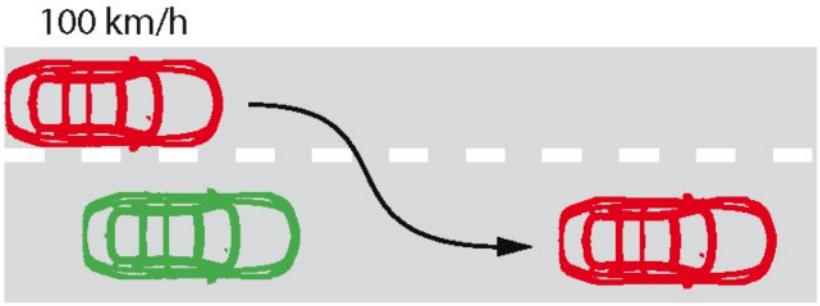
2) Following target vehicle with variable speed



ACC control

velocity ramp:
80 km/h - 100 km/h - 80 km/h

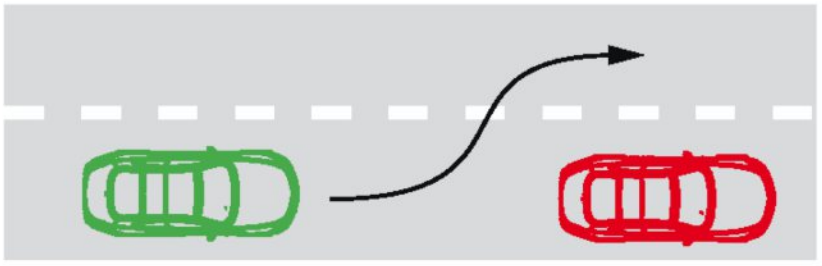
3) Cut-In of second target vehicle



ACC control

95 km/h

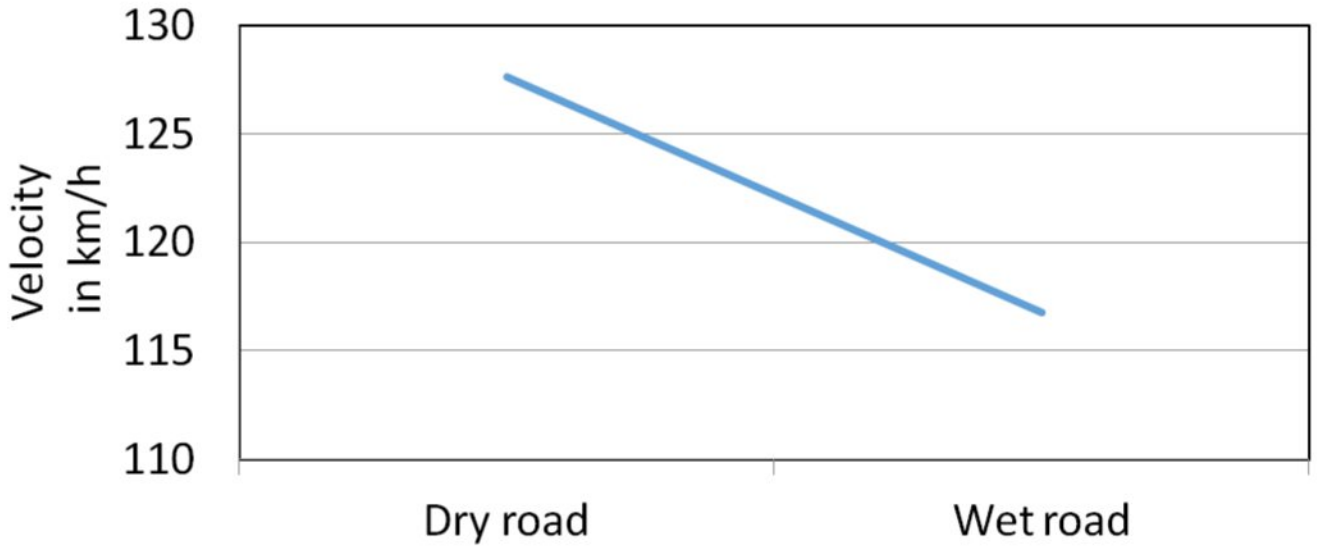
4) Overtaking target vehicle



ACC control,
ACC set speed:
100-130 km/h

95 km/h

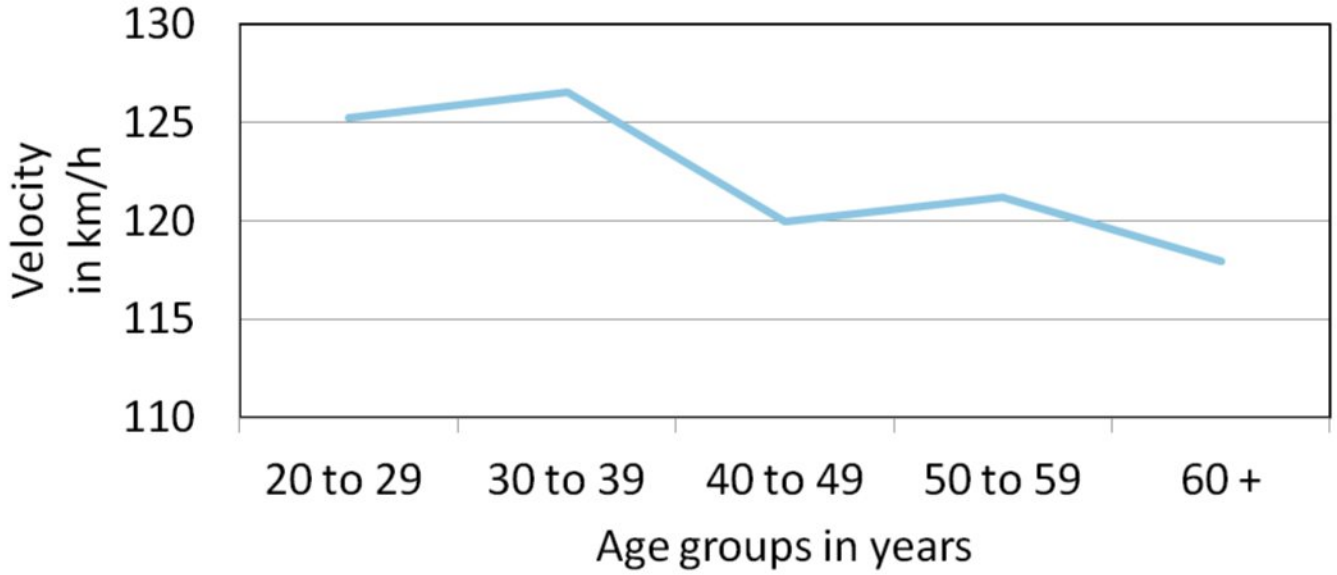
Selection of ACC set speed on the highway



Wahl einer niedrigeren Geschwindigkeit bei Schneefahrbahn als bei trockener Fahrbahn

Gender n.s.

Selection of ACC set speed on the highway



The age group of **60 +** selects a significant lower ACC speed (*M*=118, *SD*=1.50 km/h) than the age groups of

- **20-29** (*M*=125.25, *SD*=1.34 km/h) and
- **30-39** (*M*=126.59, *SD*=1.34 km/h)

Kinematic data

Kinematic Variable	Scenery and Coefficient of Friction	Mean (M)	Standard Deviation (SD)	95% Confidence Interval	
				Lower Limit	Upper Limit
Speed set by the driver (m/s)	Summer (μ=1)	35.48	0.17	35.14	35.82
	Winter (μ=0.5)	32.55	0.30	31.97	33.14
Distance gap at begin of the ACC reaction (m)	Summer (μ=1)	179.78	1.80	176.20	183.35
	Winter (μ=0.5)	169.40	1.87	165.68	173.12
Mean deceleration of the ACC (m/s^2)	Summer (μ=1)	-0.84	0.01	-0.85	-0.82
	Winter (μ=0.5)	-0.72	0.01	-0.74	-0.70
Maximal jerk of the ACC deceleration (m/s^3)	Summer (μ=1)	11.14	0.45	10.25	12.03
	Winter (μ=0.5)	8.53	0.40	7.74	9.31
Mean acceleration of the ACC (m/s^2)	Summer (μ=1)	0.51	0.004	0.50	0.51
	Winter (μ=0.5)	0.48	0.01	0.47	0.49
Maximal jerk of the ACC acceleration (m/s^3)	Summer (μ=1)	5.30	0.26	4.78	5.82
	Winter (μ=0.5)	3.86	0.17	3.52	4.21
Distance gap after the ACC reaction (m)	Summer (μ=1)	34.38	0.16	34.07	34.69
	Winter (μ=0.5)	35.13	0.19	34.75	35.51

Source: Koglbauer, I., Holzinger, J., Eichberger, A., & Lex, C., "Drivers' Interaction with Adaptive Cruise Control on Dry and Snowy Roads with Various Tire-Road Grip Potentials," Journal of Advanced Transportation, vol. 2017, Article ID 5496837, 10 pages, 2017. doi:10.1155/2017/5496837

Subjective safety and trust

- Drivers' ratings of safety and trust in the ACC were lower in the snowy road condition ($p < .10$)
- Trust in the ACC varies by age (lower in the group 20-29 than in the group 50-59 years)
- Driving with ACC on the snowy road was more mentally, physically and temporally demanding than driving on a dry road
- Gender n.s.

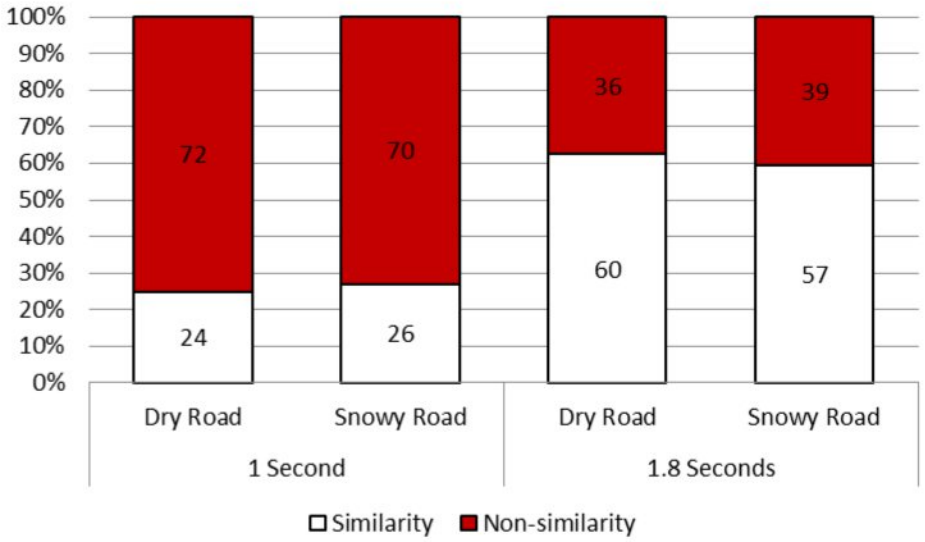
ACC gap 1 vs. 1.8 seconds

Die Abstandeinstellung des ACC (1 Sek. vs. 1,8 Sek.) hat eine **signifikante Wirkung** auf das menschliche Erleben der Fahrsituation

Beim Fahren mit der kleineren Abstandeinstellung (1 Sek.):

- Höhere mentale Beanspruchung, Anstrengung, Frustration
- Weniger Vertrauen in ACC und subjektive Sicherheit

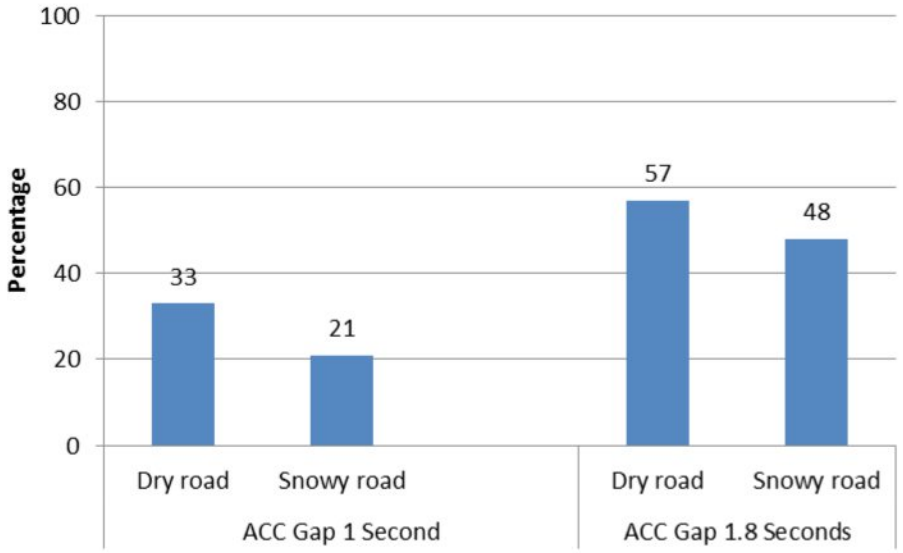
Reaction similarity driver - ACC



- Similarity with the 1.8 Seconds ACC gap more frequently reported
- Age and gender n.s.

Source: Koglbauer, I., Holzinger, J., Eichberger, A., & Lex, C., “Drivers’ Interaction with Adaptive Cruise Control on Dry and Snowy Roads with Various Tire-Road Grip Potentials,” Journal of Advanced Transportation, vol. 2017, Article ID 5496837, 10 pages, 2017. doi:10.1155/2017/5496837

Acceptance of ACC time gap



- Fewer drivers would accept to use the 1 Second ACC gap in snowy road conditions
- Age and gender n.s.

Source: Koglbauer, I., Holzinger, J., Eichberger, A., & Lex, C., "Drivers' Interaction with Adaptive Cruise Control on Dry and Snowy Roads with Various Tire-Road Grip Potentials," Journal of Advanced Transportation, vol. 2017, Article ID 5496837, 10 pages, 2017. doi:10.1155/2017/5496837

Discussion

Drivers' speed reduction of the ACC on snowy roads partially helped the ACC to adapt its control strategy to reduced tire-road grip:

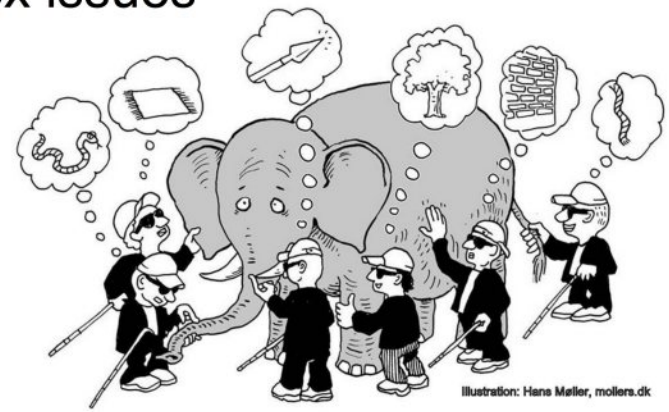
- Weaker acceleration and jerk
- Longer headway
- However, on snowy roads the ACC **started to brake** at a shorter distance to the slower forward vehicle than on dry roads.

Discussion

- Drivers considered that ACC **brakes too late** and maintains a **too short headway**, especially with the gap of 1 second.
- 96% of drivers prefer the longer ACC time gap of 1,8 s compared to the shorter gap of 1 s
- Limitations (sample, simulation)

Conclusions

- Automated driving functions should **adapt to drivers preferences and road conditions**
- The future development of automation should consider **human-machine-environment interactions**
- A **systems approach and interdisciplinary cooperation** can find proper solutions to such complex issues



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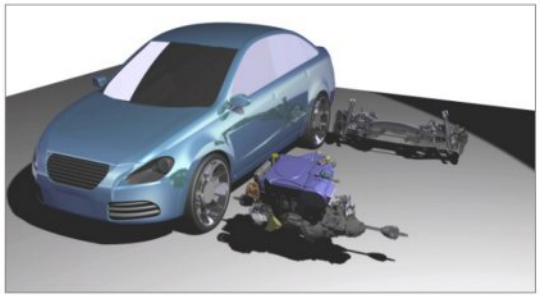

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