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ADTRANS
ADVANCED DATA ANALYSIS FOR TRANSPORTATION AND MOBILITY ACADEMIC TEACHERS

Session 1

Ethical Considerations on Autonomous Cars

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Co-funded by the European Union

Self-driving Car Companies

- Waymo
- Cruise
- Tesla
- Zoox
- Pony.AI

- Aurora
- AutoX
- Nuro
- May Mobility
- Uber

Self-Driving Car Accidents

USA in 2023

- National Highway Traffic Safety Administration (NHTSA) reported: **419 crashes**
- Level 2 Advanced Driver Assistance Systems (ADAS) reported: 18 fatalities
- Tesla vehicles with partial self-driving: 273 incidents
- Vehicles equipped with Automated Driving Systems (ADS) levels 3-5 of automation: 156 crashes, no fatalities
- Waymo vehicles: 150 crashes, making them the most frequent among companies with ADS-equipped vehicles.
- Cruise: 78 crashes, no serious injuries

Key Ethical Concerns

Who is responsible when a self-driving car gets into an accident?

Could an autonomous vehicle drive a child to school with no licensed driver in the vehicle?

How should engineers program autonomous vehicles for accident situations?

Who gets to make a decision that affects lives inside and outside the vehicle? Governments or the driver?

Key Ethical Concerns Explained

1. Safety & Reliability
2. Decision-making in critical situations
3. Accountability & Liability
4. Privacy & Data Security
5. Impact on Employment
6. Accessibility & Equity
7. Environmental Impact
8. Bias & Fairness in algorithms
9. Public Trust & Acceptance
10. Regulatory & Ethical Standards
11. Security Concerns
12. Socio-economic Impacts

1. Safety & Reliability

Waymo's robotaxi

Ensuring that autonomous vehicles (AVs) are as safe or safer than human drivers is paramount. AI-driven vehicle is more precise and consistent than a human. **The technology must be thoroughly tested to minimize accidents and fatalities.**

System Failures: As engineers, we should address how AVs should respond in the event of system failures, including ensuring fail-safes and redundancy to protect occupants and other road users.

2. Decision-Making in Critical Situations

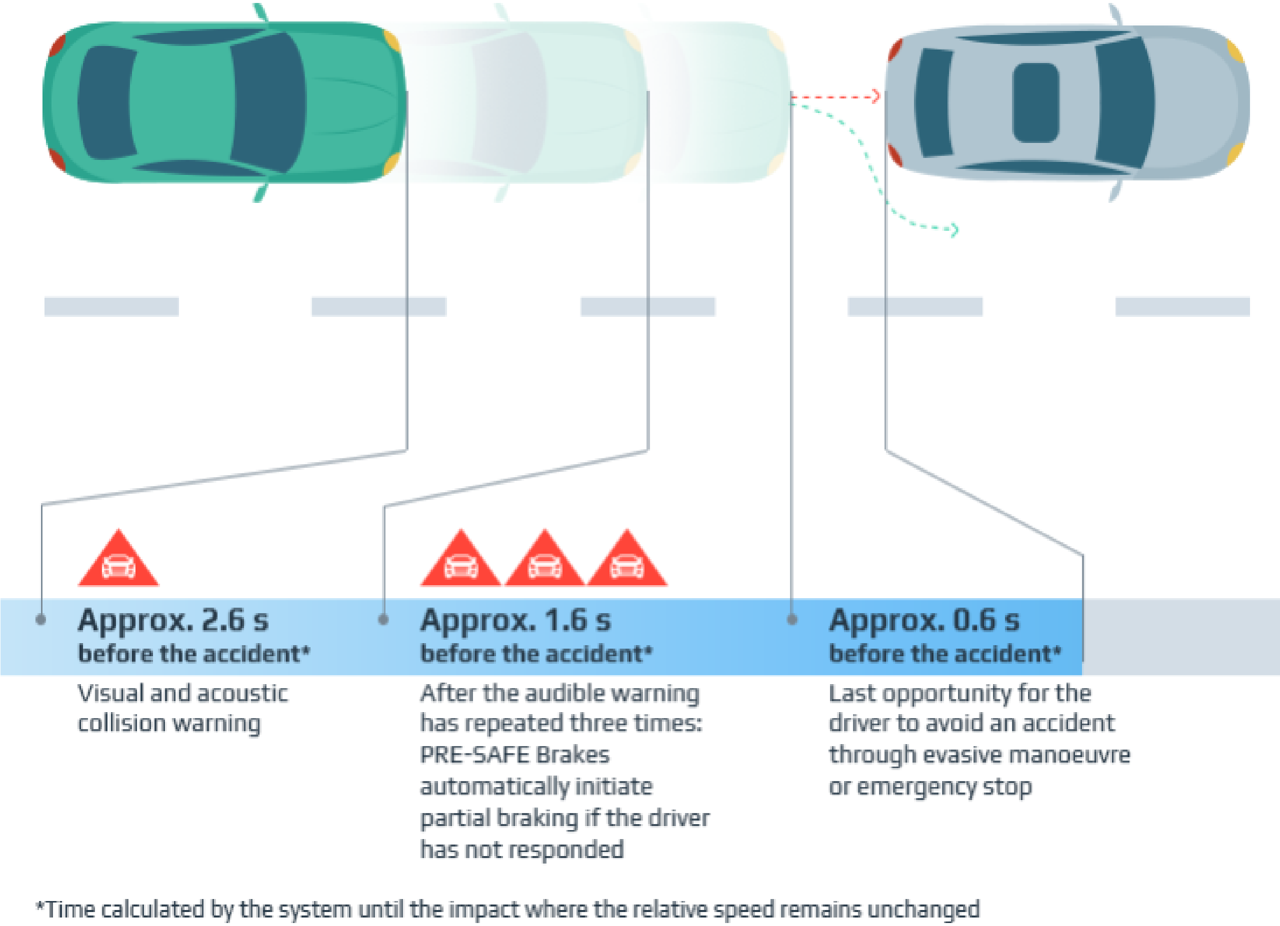
Moral Dilemmas: AVs may face situations where they must make split-second decisions, such as choosing between two harmful outcomes. These scenarios raise questions about how AVs should prioritize lives and property.

Transparency: AV manufacturers should openly disclose how their systems make critical decisions, especially in life-threatening situations. Public trust in AVs depends on clear communication about ethical programming, risk management, and real-world performance.

3. Accountability & Liability

Responsibility for Accidents: Since AVs operate autonomously, assigning liability in accidents is complex, requiring clear guidelines on whether responsibility falls on manufacturers, software developers, or users. Legal discussions continue to evolve to determine accountability based on system failures, human oversight, and real-world driving conditions.

Legal Frameworks: Governments and regulatory bodies must develop laws that clarify liability, safety standards, and insurance policies for AVs. These frameworks should ensure fair compensation for victims while encouraging responsible innovation in autonomous driving technology.



3. Accountability & Liability

Who, or what, is responsible on the road? Could an autonomous vehicle drive a child to school with no licensed driver in the vehicle? Who is liable for damages when accidents occur on the road?

Usually, this would be the person driving the car. However, one of the biggest misconceptions about AI is that these algorithms can think for themselves, which is not (yet) the case. The AI that is actually doing the driving is merely software carrying out its programming — the program itself cannot be held responsible for its actions. *Does that mean the car manufacturer is responsible for any accidents? The software developers?*

These are the type of ethical questions that government bodies will sort out. Local road laws may require a licensed driver to be in the car and ready to take over if needed. Similarly, accident liability will likely be determined based on the cause of accidents. If an accident is determined to have been caused by a technical glitch or shortcoming, only then would the manufacturer be responsible.

4. Privacy & Data Security

Data Collection: AVs collect vast amounts of data from their surroundings and occupants. Ensuring this data is collected, stored, and used in a way that respects privacy is essential.

Cybersecurity: As AVs rely on complex software, sensors, and cloud connectivity, they become potential targets for cyber-attacks. Implementing strong encryption, regular software updates, and intrusion detection systems is essential to prevent unauthorized access, protect user data, and ensure safe vehicle operations.

5. Impact on Employment

Job Displacement: The widespread adoption of AVs could lead to job losses in sectors like trucking, taxi services, and delivery. Addressing the social and economic impacts on affected workers is crucial.

New Opportunities: While autonomous vehicles may reduce the need for traditional driving jobs, they will also create new employment opportunities in areas like AV maintenance, AI system monitoring, data analysis, and cybersecurity. Workers will need to adapt to this shift by acquiring new skills in software development, robotics, and fleet management to stay relevant in the evolving job market.

Tesla’s robotaxi & robovan

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6. Accessibility & Equity

Fair Access: Autonomous technology should be developed to serve both urban and rural areas, ensuring that mobility solutions are not limited to wealthier regions. Government policies and subsidies can help bridge the gap, making AVs a viable option for all communities.

Affordability: If AVs remain too expensive, they will only benefit high-income individuals, widening transportation inequality. To prevent this, manufacturers should focus on cost-effective production, government incentives, and shared mobility models to make AVs accessible to a broader population.

7. Environmental Impact

Sustainability: AVs should be designed with energy-efficient systems, sustainable materials, and eco-friendly manufacturing processes to minimize their environmental footprint. Additionally, promoting shared autonomous mobility can help reduce traffic congestion and lower overall emissions.

Urban Planning: AV adoption may lead to fewer parking lots, enabling cities to repurpose space for green areas, bike lanes, or pedestrian zones. Smart traffic management powered by AVs could also improve road efficiency, reducing congestion and travel time.

8. Bias & Fairness in Algorithms

Algorithmic Bias: If AV algorithms are trained on biased datasets, they may fail to correctly detect pedestrians from underrepresented groups or misjudge right-of-way for cyclists, increasing safety risks. Regular audits, diverse training data, and fairness-focused AI models help minimize such biases and ensure equitable decision-making.

Inclusive Development: Collaboration with policymakers, urban planners, disability advocates, and local communities ensures AV systems are designed to serve everyone fairly. Considering diverse perspectives leads to better accessibility, improved safety, and broader public trust in the technology.

9. Public Trust & Acceptance

Public tolerance for accidents involving autonomous vehicles may be lower than for human-driven vehicles, potentially delaying the adoption of these technologies despite their safety benefits.

Building Trust: Public engagement through educational campaigns, demonstrations, and transparent discussions about AV limitations can help reduce skepticism and fear. Involving communities in the decision-making process and addressing concerns proactively fosters acceptance and confidence in the technology.

Ethical Marketing: Companies should provide clear, fact-based information about AV performance, avoiding exaggerated claims that could lead to unrealistic expectations. Honest communication about safety measures, real-world testing, and potential risks ensures consumers make informed decisions.

10. Regulatory & Ethical Standards

Global Driving Standards Certification

- **Global Standards:** Developing international standards and regulations is crucial to ensure consistency and safety in AV technology across different countries and regions. These standards help create a unified framework for testing, deployment, and data sharing.

- **Ethical Guidelines:** Ethical guidelines for the development and deployment of AVs should be established to guide manufacturers, developers, and policymakers. These guidelines ensure responsible development, prevent bias in AI systems, and promote public trust in autonomous technology.

11. Security Concerns

Putting a computer in control of something as potentially dangerous as a car may lead to more risks than it removes. For example, it creates room for potential hacking incidents that could be fatal.

Hackers have already figured out how to remotely hack and take control of vehicles, even those that aren't self-driving. With autonomous vehicles, this danger is heightened, since the vehicle would have to be connected to the internet for things like software updates and GPS. A hacker could carjack someone while they were driving, anonymously steal their car in the middle of the night or remotely unlock their doors.

From an ethical standpoint, is this situation safer than the risks of human error on the road? Considering the rising rates of cybercrime, some may argue self-driving cars pose too great a security risk to go mainstream.

12. Socio-Economic Impacts

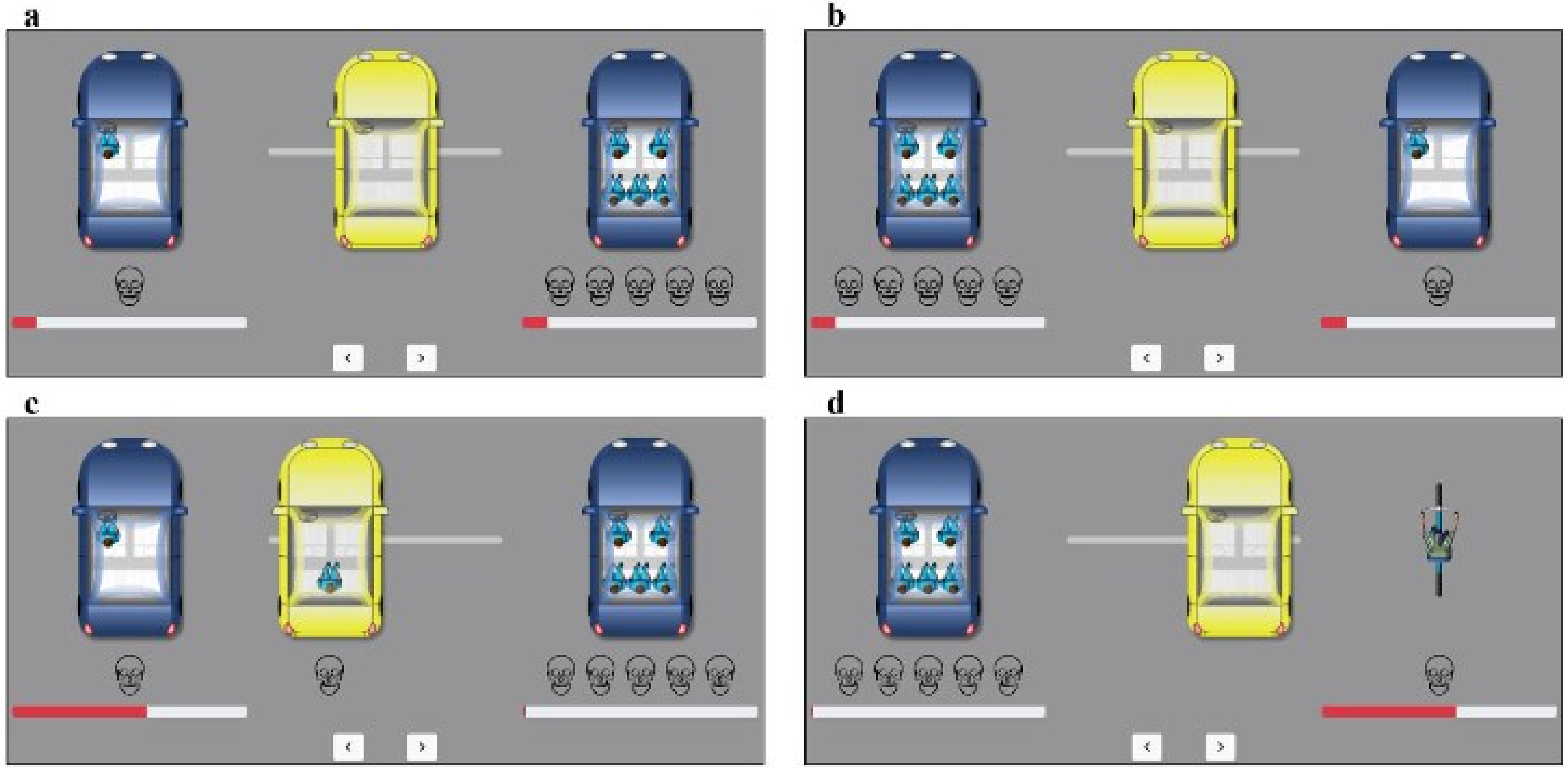
There is a risk that autonomous vehicles could exacerbate socio-economic disparities. For example, if fast passage on roads can be bought, it may lead to a segregation of traffic based on wealth.

This could create a divide where wealthier individuals gain access to faster, less congested routes, while lower-income commuters face longer travel times and reduced accessibility.

Over time, such a system might reinforce social inequality, limiting mobility opportunities for economically disadvantaged groups and deepening existing disparities in urban infrastructure.

Ethical Test

Where do you think the yellow self-driving car should drive?



The figure shows four traffic situations of a self-driving car.
The probability of collision with another road user was very small, but not zero. The smaller the distance, the higher the probability of a collision.
If a collision occurred, all involved parties were dead.
The self-driving car could not collide with both other road users simultaneously.

Ethical Test

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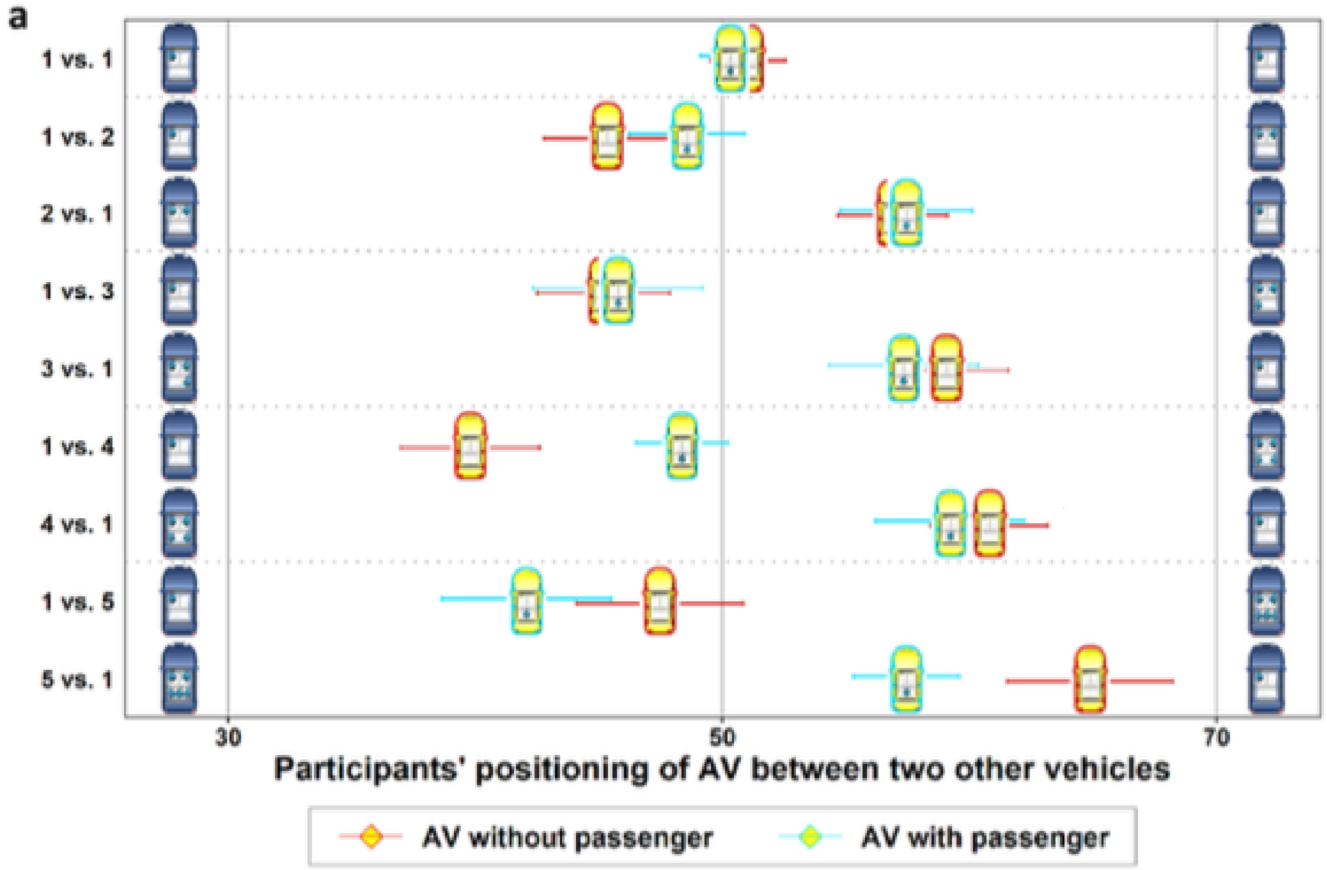
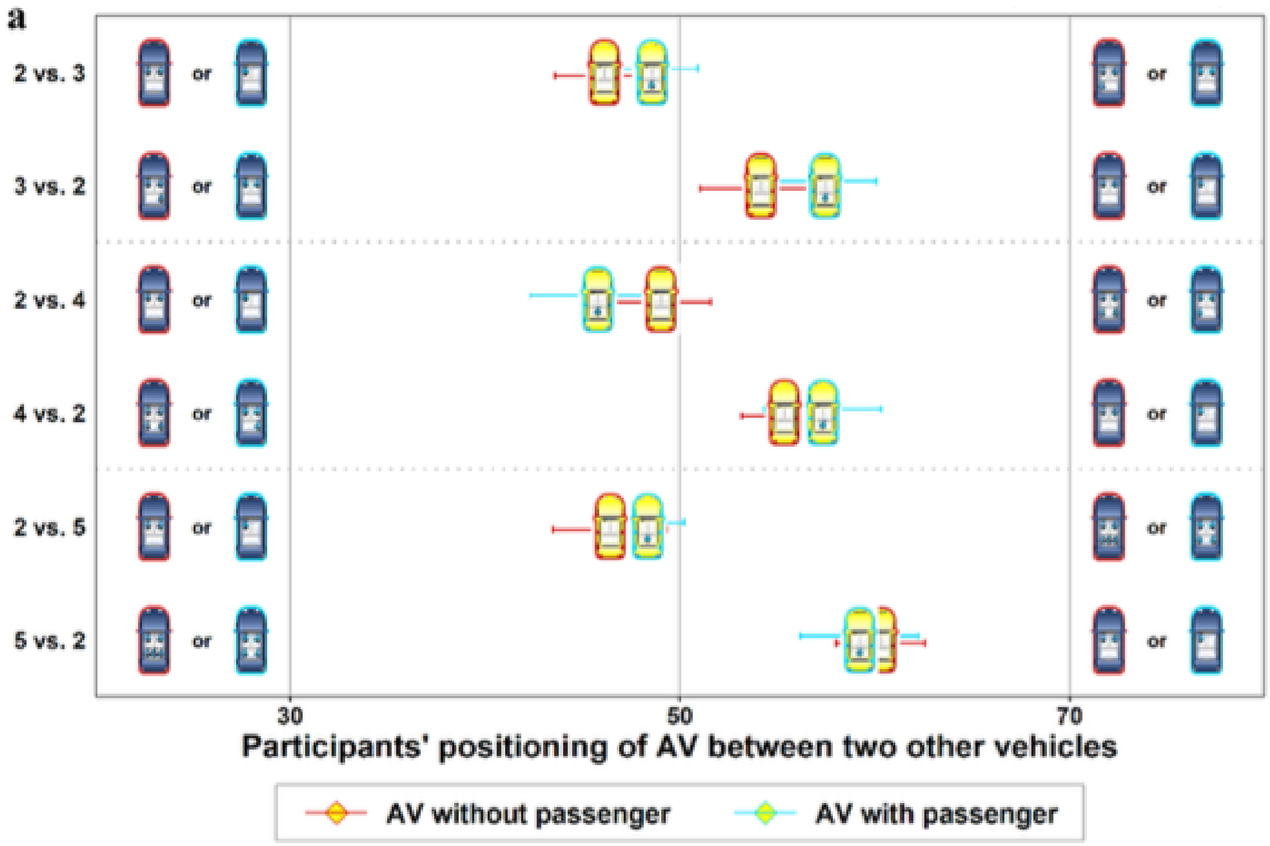


Risk allocation between road users of the same type.
Means and standard errors of participants' positioning of the AV with different numbers of passengers in the blue cars on the left and right sides. Avs with red frames depict the results when the AVs were empty; those with blue frames show the results when the participants were passengers in the AV.

Ethical Test

Where do you think the yellow self-driving car should drive?

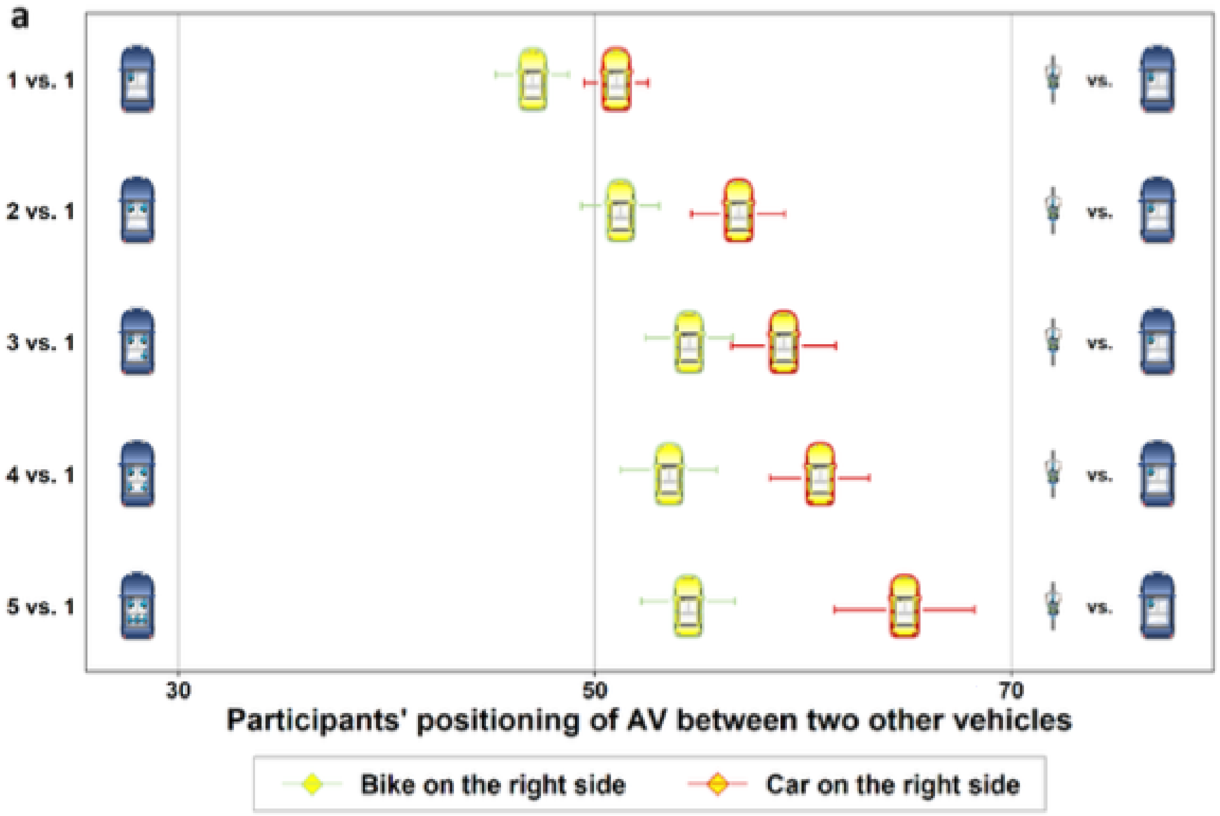


Risk allocation between road users of the same type when the passenger of the AV is taken into account as a collision victim.

(a) Means and standard errors of participants' positioning of the AV with different numbers of passengers in the blue cars on the left and right sides. Red frames depict the results when the AVs were empty; those with blue frames show the results where the participants were a passenger in the AV.

Ethical Test

Where do you think the yellow self-driving car should drive?



Risk allocation between different types of road users.

Means and standard errors of participants' positioning of the AV with different numbers of passengers in the blue car on the left side and different road users on the right side.
AVs with red frames depict the results when there was a car on the right side; those with green frames show the results when there was a cyclist on the right side.

Ethical Test Results

Where do you think the yellow self-driving car should drive?

Treatments	Number of people on left side					Number of people on right side
	1	2	3	4	5	
AV without passenger; A car on each side of the road.	106	41	53	56	52	1
	41	---	43	51	49	2
	54	57	---	---	---	3
	45	53	---	---	---	4
	44	52	---	---	---	5
AV with passenger; A car on each side of the road.	103	43	49	52	52	1
	46	---	---	---	---	2
	51	---	---	---	---	3
	49	---	---	---	---	4
	44	---	---	---	---	5
AV w/o passenger; Bike on the right side of the road	121	99	87	109	105	1

Number of observations in each traffic situation in our test.
Cells shaded alike in the same section of the table indicate paired traffic situations that differed only in terms of whether the majority of road users appeared on the left or right side of the road.

Ethical Standards

1. European Commission’s Ethics Guidelines for Trustworthy AI

Its **purpose** is to provide a framework to ensure AI systems are lawful, ethical, and robust, applicable to autonomous driving technologies.

Reference:
https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai

Key Principles

Human Agency and Oversight:

- Ensuring human control and intervention capabilities.

Technical Robustness and Safety:

- Guaranteeing the system's safety and resilience.

Privacy and Data Governance:

- Protecting data and ensuring privacy.

Transparency:

- Providing clear and transparent AI system operations.

Diversity, Non-discrimination, and Fairness:

- Avoiding biases and ensuring fairness.

Societal and Environmental Well-being:

- Promoting positive societal and environmental impacts.

Accountability:

- Establishing mechanisms for accountability and responsibility.

Ethical Standards

2. IEEE 7009-2024 – Standard for Fail-Safe Design of Autonomous Systems

Its **purpose** is to establish methodologies and tools for developing effective fail-safe mechanisms in autonomous systems.

Reference: https://standards.ieee.org/ieee/7009/7096/

Key Principles

Human Rights:
Respect for human rights and dignity.

Well-being:
Promoting well-being and preventing harm.

Accountability:
Ensuring accountability and responsibility.

Transparency:
Maintaining transparency and explainability of AI systems.

Fairness:
Ensuring fairness and avoiding bias in AI systems.

Ethical Standards

3. ISO 39001:2012 – Road Traffic Safety (RTS) Management Systems

Its purpose is to provide guidelines for a road traffic safety management system to reduce deaths and serious injuries from traffic accidents.

Reference: https://www.iso.org/standard/44958.html

Key Principles

Safety First:
- Ensuring the safety of all road users.

Responsibility:
- Clear assignment of responsibility during trials.

Data Recording:
- Ensuring robust data recording for accountability.

Transparency:
- Publicly accessible information about the trials.

Ethical Standards

4. Ethical Framework by the German Ethics Commission on Automated and Connected Driving

The purpose is to address the ethical implications of automated driving.

Reference: https://link.springer.com/article/10.1007/s13347-022-00526-2

Key Principles

Priority of Human Life:

- Protecting human life above all else.

Individual Responsibility:

- Clarifying the roles and responsibilities of users and manufacturers.

Data Protection:

- Ensuring robust data protection measures.

Risk Minimization:

- Minimizing risks through technical and legal means.

Ethical Standards

5. ISO 26262-2018 : Functional Safety for Road Vehicles

Its purpose is to provide a standard for ensuring the functional safety of electrical and electronic systems in vehicles.

Reference: https://www.iso.org/standard/68383.html

Key Principles

Safety Lifecycle:

- Addressing safety throughout the lifecycle of the vehicle.

Hazard Analysis and Risk Assessment:

- Identifying and mitigating risks.

Verification and Validation:

- Rigorous testing and validation of safety measures.

Ethical Standards

6. Asilomar AI Principles

The purpose of these 23 principles is to provide broad guidelines for AI research, development and deployment including autonomous vehicles. The guidelines also ensure that AI systems are safe, transparent, and aligned with human values.

Reference:
https://futureoflife.org/open-letter/ai-principles/

Key Areas Covered

Research Goal:
- The goal of AI research should be to create beneficial intelligence.

Ethics and Values:
- AI should align with human values and ethics.

Safety and Security:
- Ensuring AI systems are safe and secure.

Transparency:
- Open research and collaboration.

End of Session 1