

Perceived safety and comfort of pedestrian interactions with self-driving vehicles

Recommendations for responsible introduction of self-driving vehicles

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INTRODUCTION



CONTEXT

- Public agencies have been promoting **active modes of travel**
- Providing better facilities could increase active mode share
- But feeling **safe** and **comfortable** while travelling is also important

Transport 2050:
“If people enjoy their transportation experience, they are **more likely to travel**.....
A key part of this is feeling **comfortable, safe,**
and secure when travelling”

Better facilities
for active mode
users



Promote active modes
Goal of Transport 2050:
“By 2050, **active transportation**
and transit are competitive
choices accounting for at least
half of all passenger trips.”

CONTEXT

- In parallel to active modes, public agencies are also promoting self-driving vehicles (SDVs)
- Both promotions are expected to align, as SDVs could improve safety and accessibility

Transport 2050:
“If people enjoy their transportation experience, they are more likely to travel.....
A key part of this is feeling comfortable, safe, and secure when travelling”

Better facilities
for active mode
users



Promote active modes

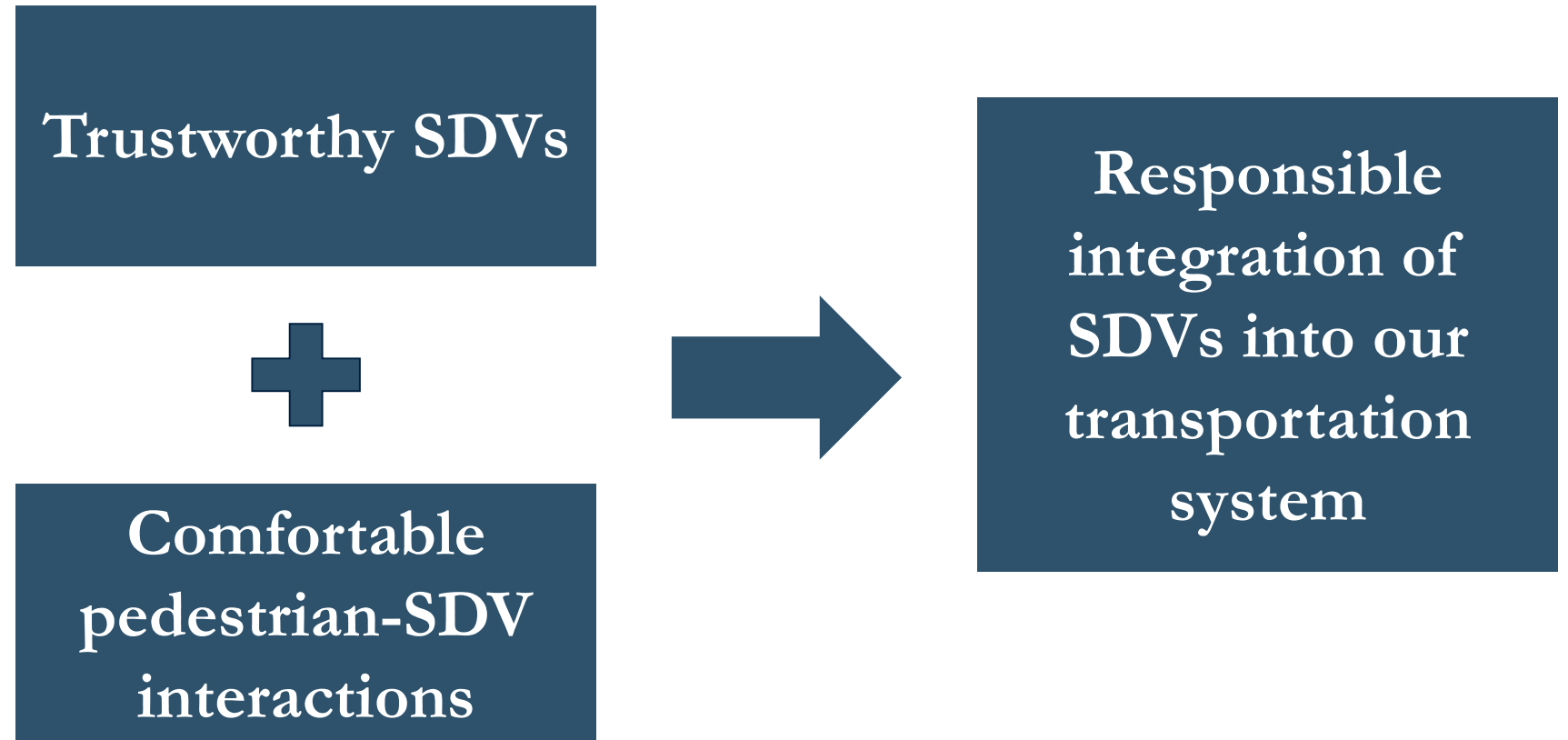
Goal of Transport 2050:
“By 2050, **active transportation** and transit are competitive choices accounting for at least **half** of all passenger trips.”

Promote self-driving vehicles (SDVs)

Transport 2050:
“By 2050, connected and **automated vehicles** could be carrying a majority of passenger and freight trips in the region.”

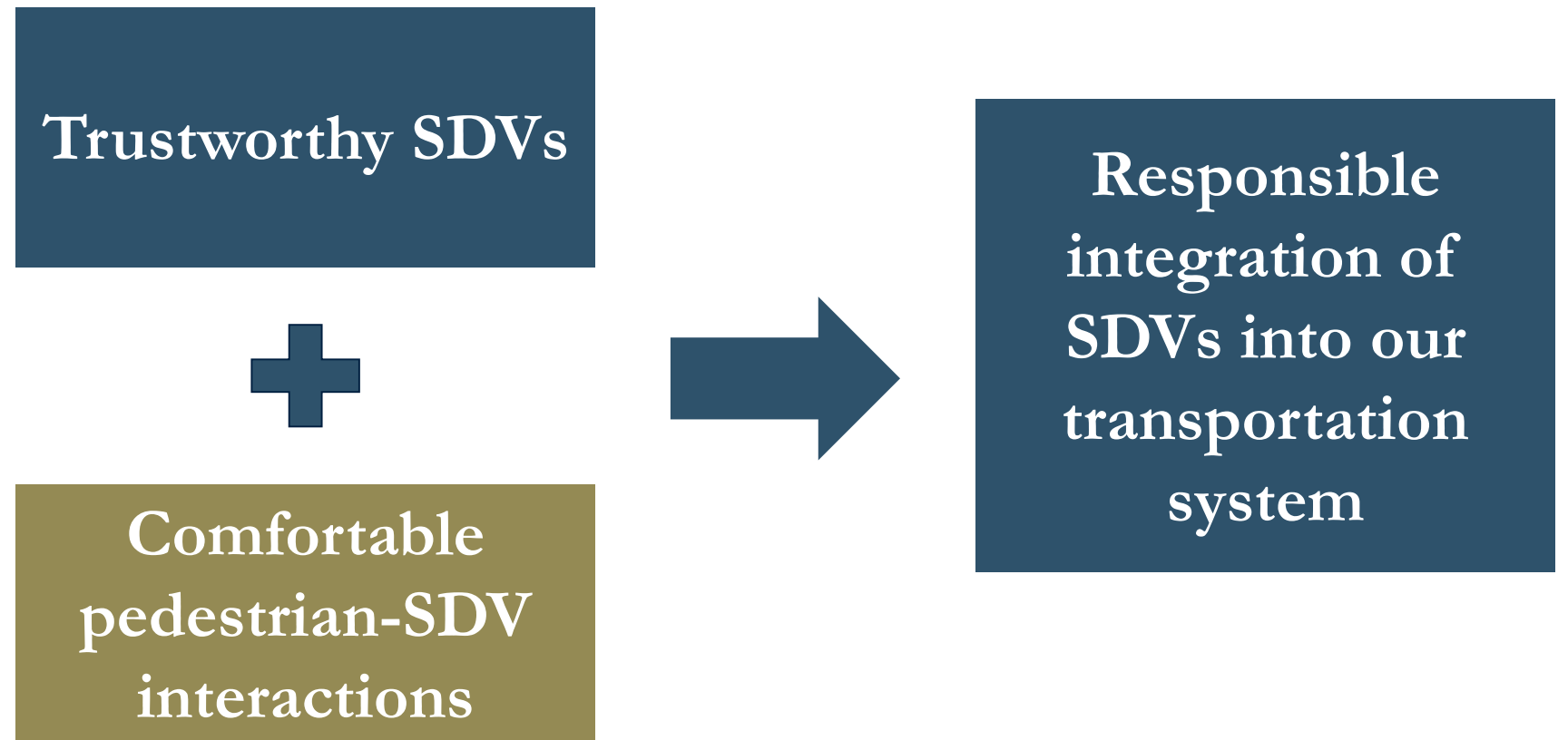
CHALLENGE

- For integrating SDVs responsibly (i.e., SDVs support active modes rather than degrade their experience), there are two components:
 - Having advanced, trustworthy SDV technology
 - Comfort of active travellers, including the quality of pedestrian-SDV interactions
- Perceptions of **comfort** and **safety** are crucial to responsible integration
 - Maintain walkable public streets
 - Influence acceptance/support for SDV integration policies



GOAL OF THIS STUDY

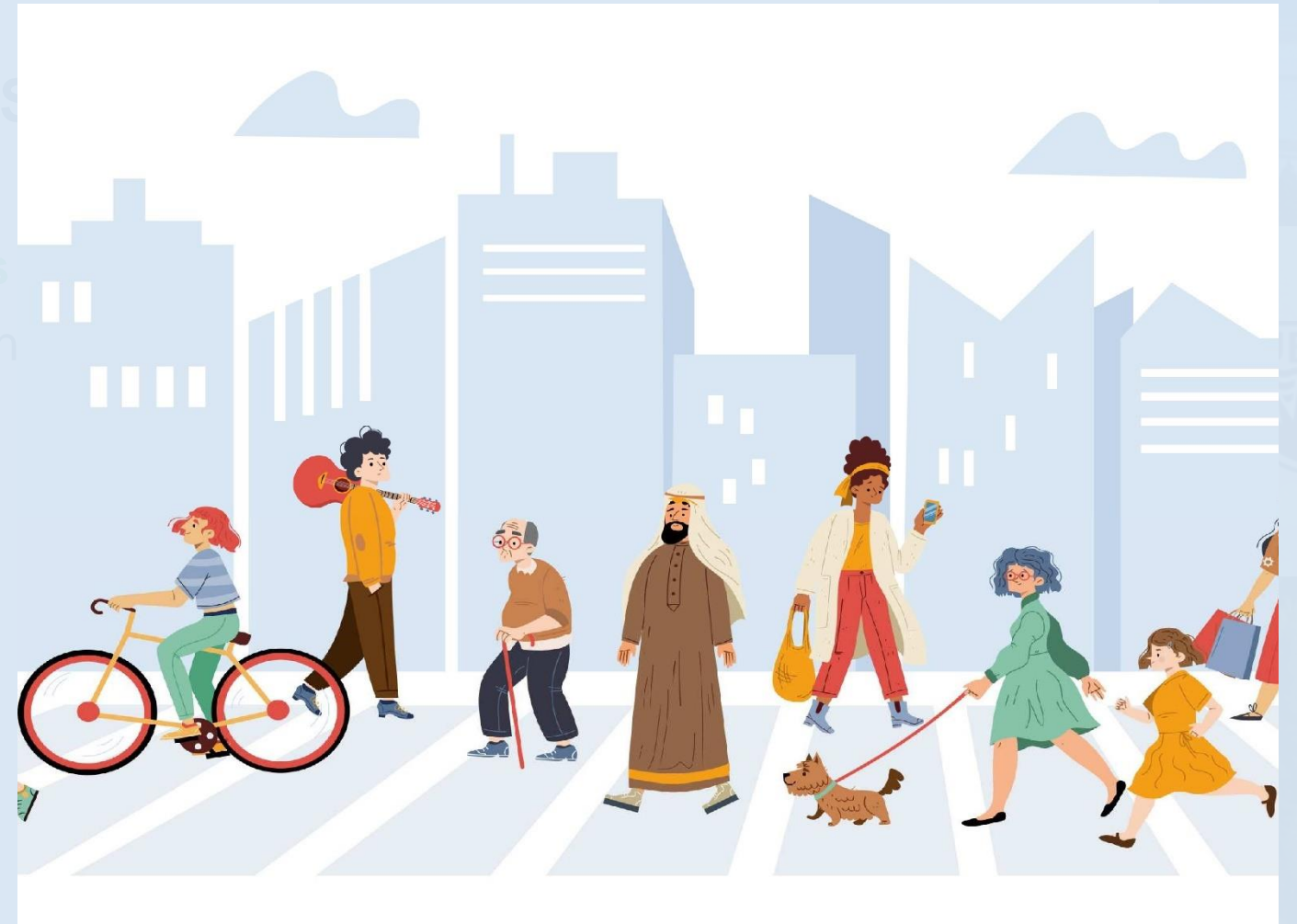
- Most focus up to now has been on SDV technology
- We focus on understanding **pedestrian-SDV interactions** so that:
 - We can propose realistic policies to inform a strategy for responsible introduction of SDVs
 - We can maintain quality of current walking experience in future



WE INVESTIGATE 3 RESEARCH QUESTIONS

Pedestrian-SDV interactions:

- Studies have examined how SDVs' communication or operational characteristics influence perceptions
- But no study has examined the core question: how does SDVs' defining characteristic – vehicle autonomy – influence perceptions?



WE INVESTIGATE 3 RESEARCH QUESTIONS (RQ)

1. Do people perceive pedestrian interactions with **SDVs** as more or less comfortable and safe than interactions with **HDVs**, controlling for all other differences?
 - (i.e., is there an “**Autonomy Bias**”)?



Pedestrian-SDV interactions:

- Perceptions are subjective
 - (i.e., is there an “Autonomy Bias”)?
- Perceptions vary by personal attributes
- Perceptions influence SDV policy



WE INVESTIGATE 3 RESEARCH QUESTIONS (RQ)

1. Do people perceive pedestrian interactions with **SDVs** as more or less comfortable and safe than interactions with **HDVs**, controlling for all other differences?
 - (i.e., is there an “**Autonomy Bias**”)?
2. Does the **Autonomy Bias** vary systematically within the **population** (e.g. with age, gender, race, travel habits, and so on)?
3. Which **personal attributes**, including Autonomy Bias, determine support for various **SDV policies**?



METHODS



SURVEY DATA

- Survey was advertised on Facebook and Instagram

Survey advertisement

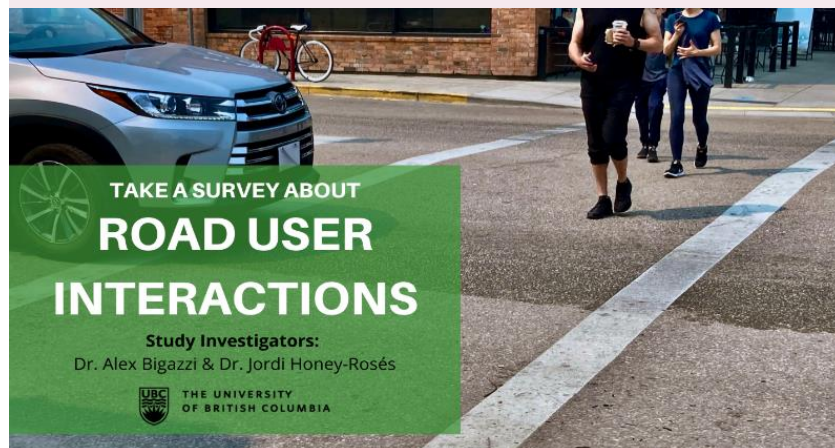
We are looking for participants who travel in British Columbia to take our survey.

Participation requires between 10 and 15 minutes and involves viewing and rating a series of video clips of real-world interactions.

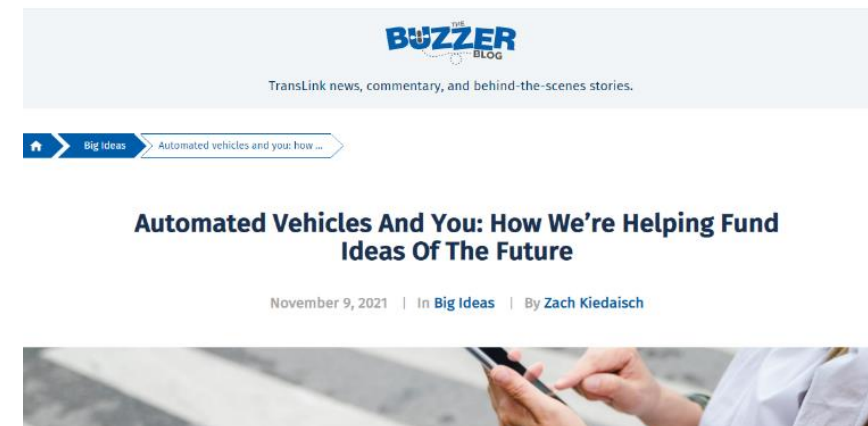
All participants will have a chance to enter into a draw for one of ten gift cards of \$25 each.

To participate, or get more information, please visit tinyurl.com/react-lab-survey...

Note that if you like, follow, or comment on this post, others may associate your profile with this study.



- It was promoted by TransLink and UBC



SURVEY DESIGN

1. Introduction and consent
2. SDV-related questions
 - Familiarity
 - Affective response (level of anxiety/enthusiasm) to SDV technology
 - Intention to ride in SDVs
 - Support for SDV policies



Support for SDV policies (strongly disagree to strongly agree):

Policies were realistic, relevant to pedestrians, comparable to literature, and useful for near-term decisions to introduce SDVs

SDV acceptance for SDV policies

- Allowing **shared SDVs** to operate on public roads
- Allowing **privately-owned SDVs** to operate on public roads

SDV operations and features

- Allowing SDVs to travel at the **same speed** as HDVs (vs. slower)
- Allowing SDVs to enter **pedestrian priority areas**, such as near schools
- Allowing SDVs to operate **without a person** in the driver's seat
- Allowing SDVs to operate **without being clearly identified** to other road users



SURVEY DESIGN

1. Introduction and consent
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 - Familiarity
 - Affective response (level of anxiety/enthusiasm) to SDV technology
 - Intention to ride in SDVs
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3. Deception-based experiment (interaction ratings)



SURVEY DESIGN

1. Introduction and consent

Deception-based experiment:

- Participants evaluate severity of interactions
- Vehicle described as “self-driving vehicle” or “regular vehicle”
- Both are (same) regular vehicles in reality
- All participants rate the same 8 videos



Regarding the interaction between the crossing pedestrian and the **self-driving vehicle** shown in the video, please indicate your level of agreement with the statements below:

Strongly disagree -10 Neither disagree nor agree 0 Strongly agree 10

The vehicle yielded to the pedestrian. I don't know



The vehicle *should have* yielded to the pedestrian. I don't know



The pedestrian felt comfortable in this crossing. I don't know



The risk of injury for the pedestrian in this crossing was low. I don't know



Regarding the interaction between the crossing pedestrian and the **regular vehicle** shown in the video, please indicate your level of agreement with the statements below:

Strongly disagree -10 Neither disagree nor agree 0 Strongly agree 10

The driver yielded to the pedestrian. I don't know



The driver *should have* yielded to the pedestrian. I don't know



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SURVEY DESIGN

1. Introduction and consent
2. SDV-related questions
 - Familiarity
 - Affective response (level of anxiety/enthusiasm) to SDV technology
 - Intention to ride in SDVs
 - Support for SDV policies
3. Deception-based experiment (interaction ratings)
4. Personal attributes
 - Socio-demographics (age, gender, income, race, etc.)
 - Travel habits (travel frequency using different modes)
 - Other personal attributes (risk aversion, early technology adopter, etc.)
5. Determine if deception was effective or not
6. Reveal deception and confirm consent



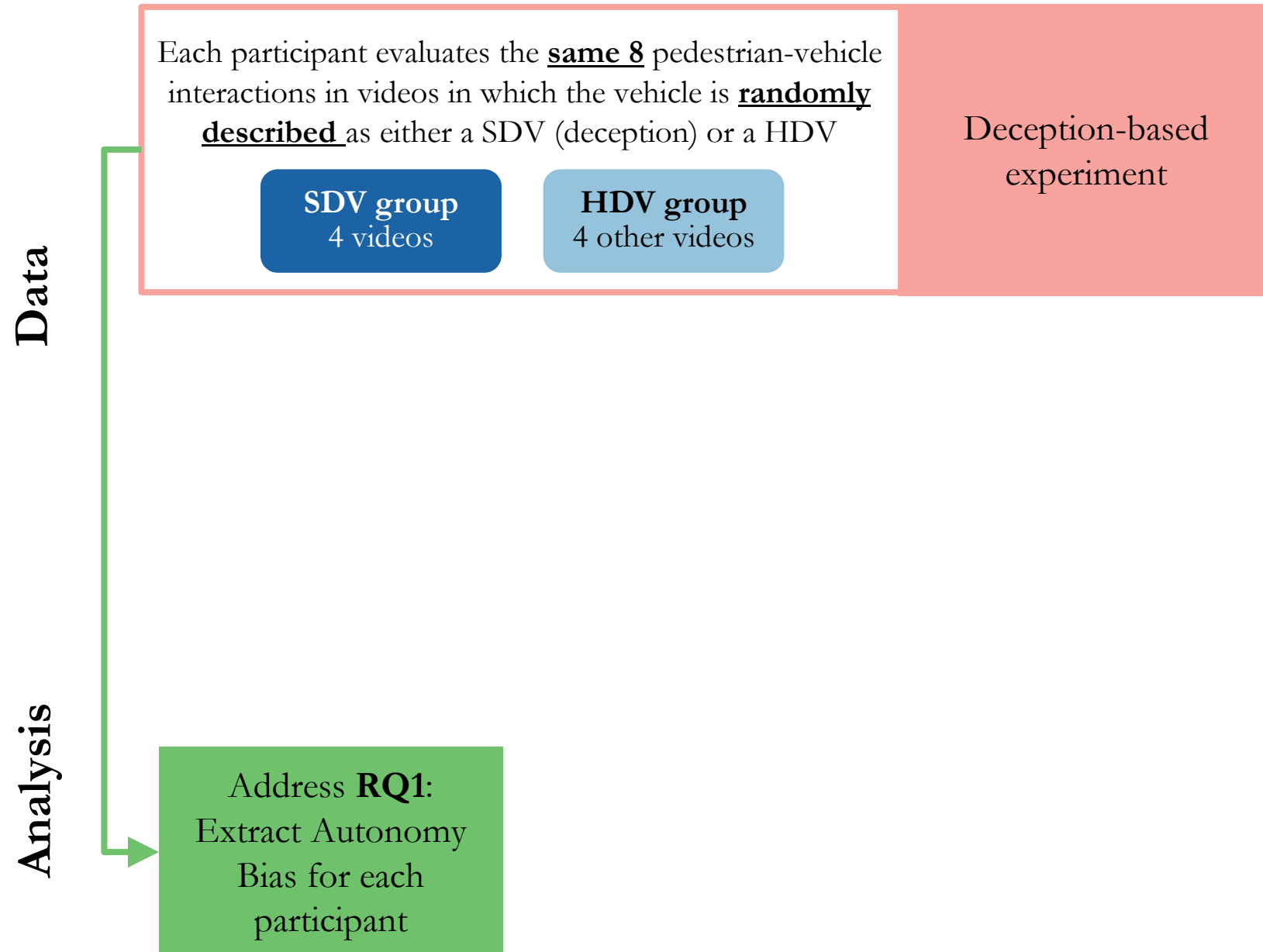
SURVEY DESIGN

1. Introduction and consent
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 - Socio-demographics (age, gender, income, race, etc.)
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 - Other personal attributes (risk aversion, early technology adopter, etc.)
5. Determine if deception was effective or not

96% of the participants were deceived by our experiment, mainly because of their trust in authority (UBC researchers) and the SDVs in our videos meeting their expectations of SDV behaviour.



OVERVIEW OF METHODS



OVERVIEW OF METHODS

We observe Autonomy Bias from ratings:

- If a person has no Autonomy Bias, ratings of yielding, comfort, and safety should be same
- If a person has **negative** Autonomy Bias (i.e., bias *against* SDVs), they will rate SDV interactions as **less comfortable and less safe** than a HDV
- If a person has **positive** Autonomy Bias (i.e., bias *in favour of* SDVs), they will rate SDV interactions as **more comfortable and safer** than a HDV

Analysis

Address RQ1:
Extract
Autonomy Bias
for each
participant



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The driver *should have* yielded to the pedestrian. I don't know



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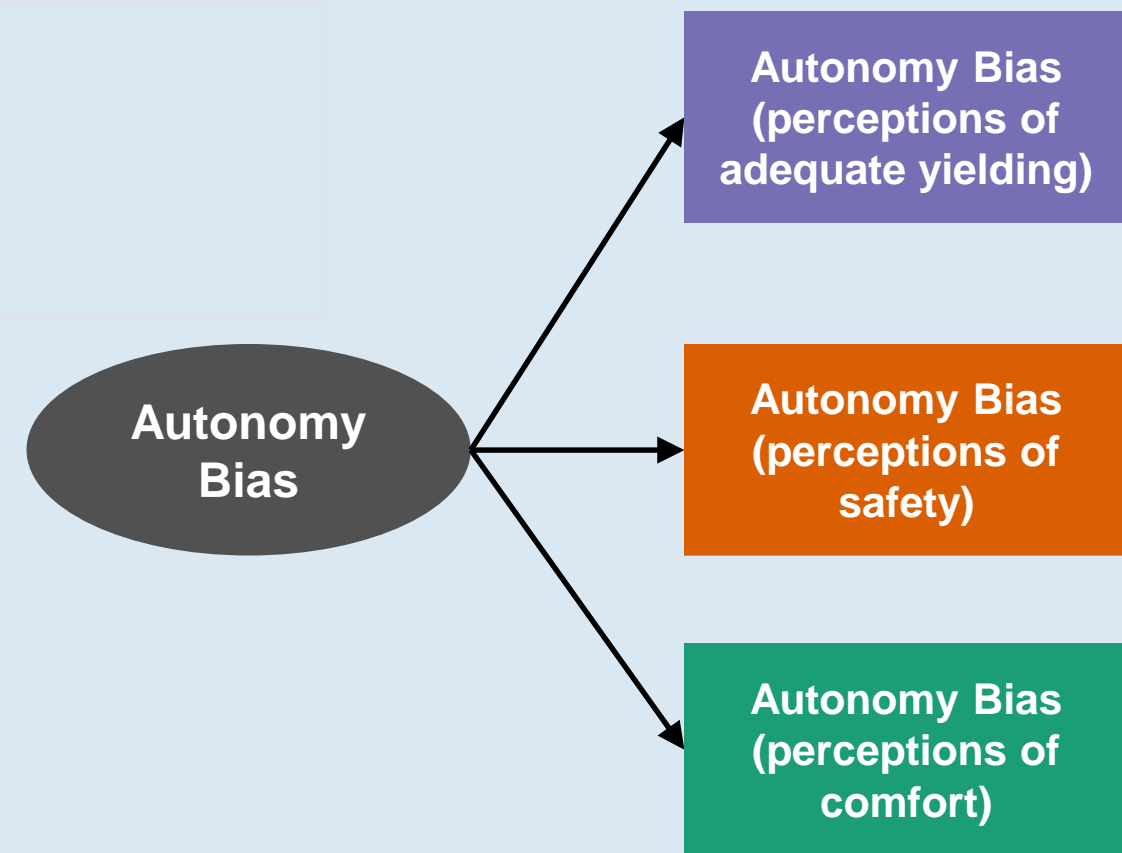


The risk of injury for the pedestrian in this crossing was low. I don't know

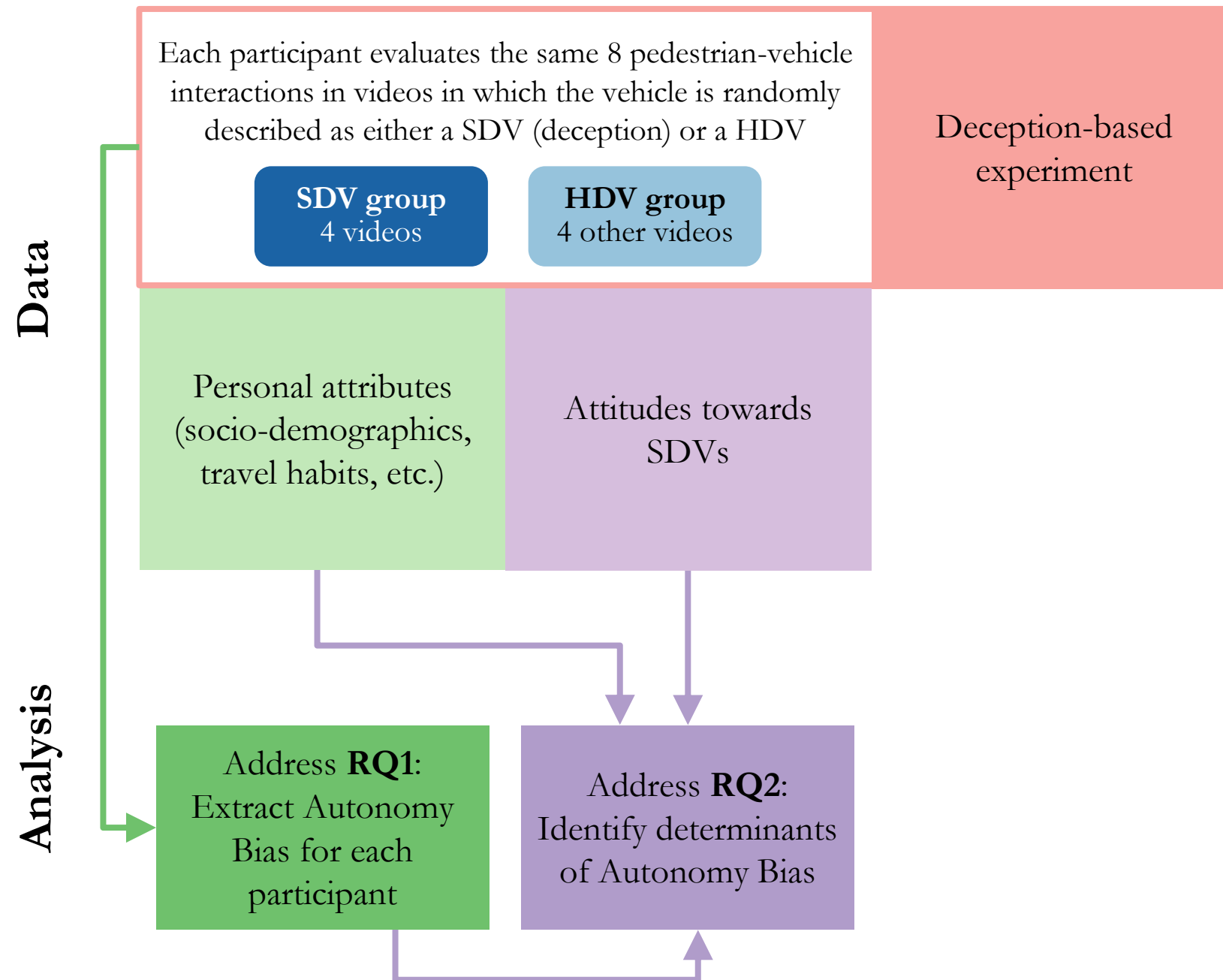


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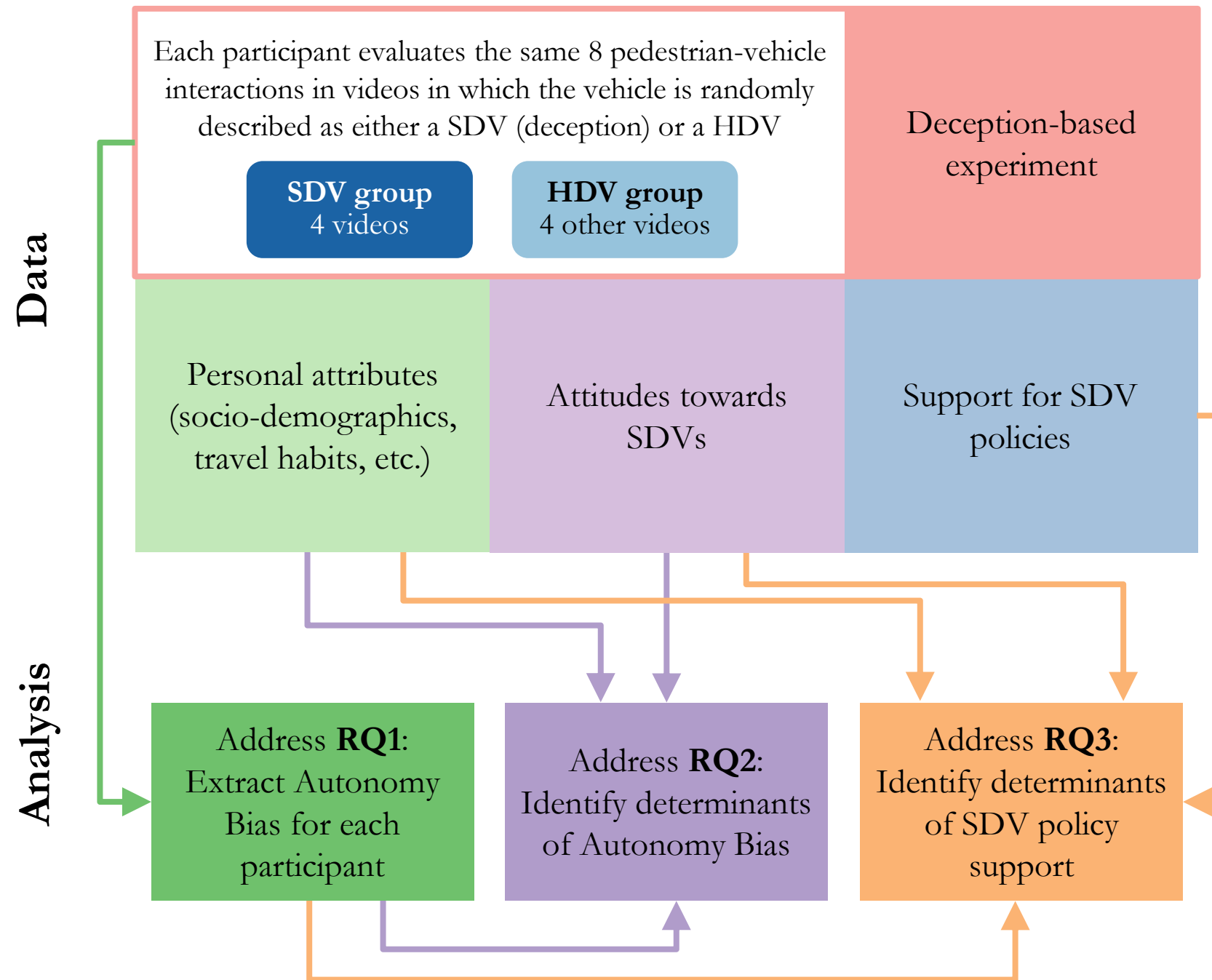
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- We conceptualize that the underlying Autonomy Bias influences how a person perceives yielding of the SDV, and safety and comfort of the crossing pedestrian (as shown by the direction of arrows).
- We use regression to extract each person's Autonomy Bias



OVERVIEW OF METHODS



OVERVIEW OF METHODS



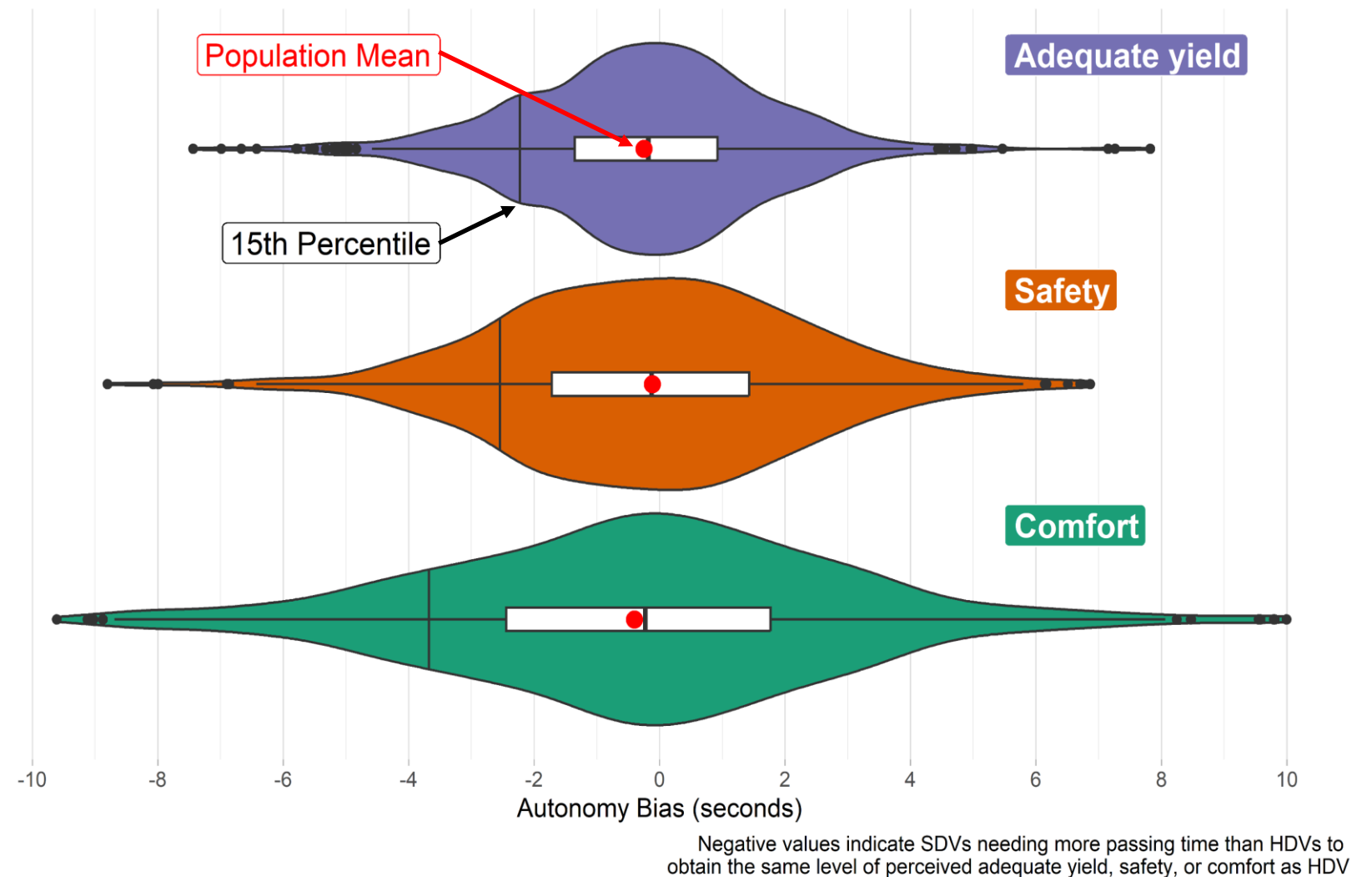
RESULTS AND FINDINGS



RESULTS AND FINDINGS

- All three means of Autonomy Bias are slightly **negative** (>95% confidence), indicating that the BC population has a bias *against* SDVs (i.e., perceives SDVs less favourably than HDVs)
- Autonomy Bias (comfort) has the largest magnitude and variability
- For 85% of the population to feel as comfortable with SDVs as HDVs, SDVs would need to give at least 3.7 seconds more than HDVs when interacting with pedestrians

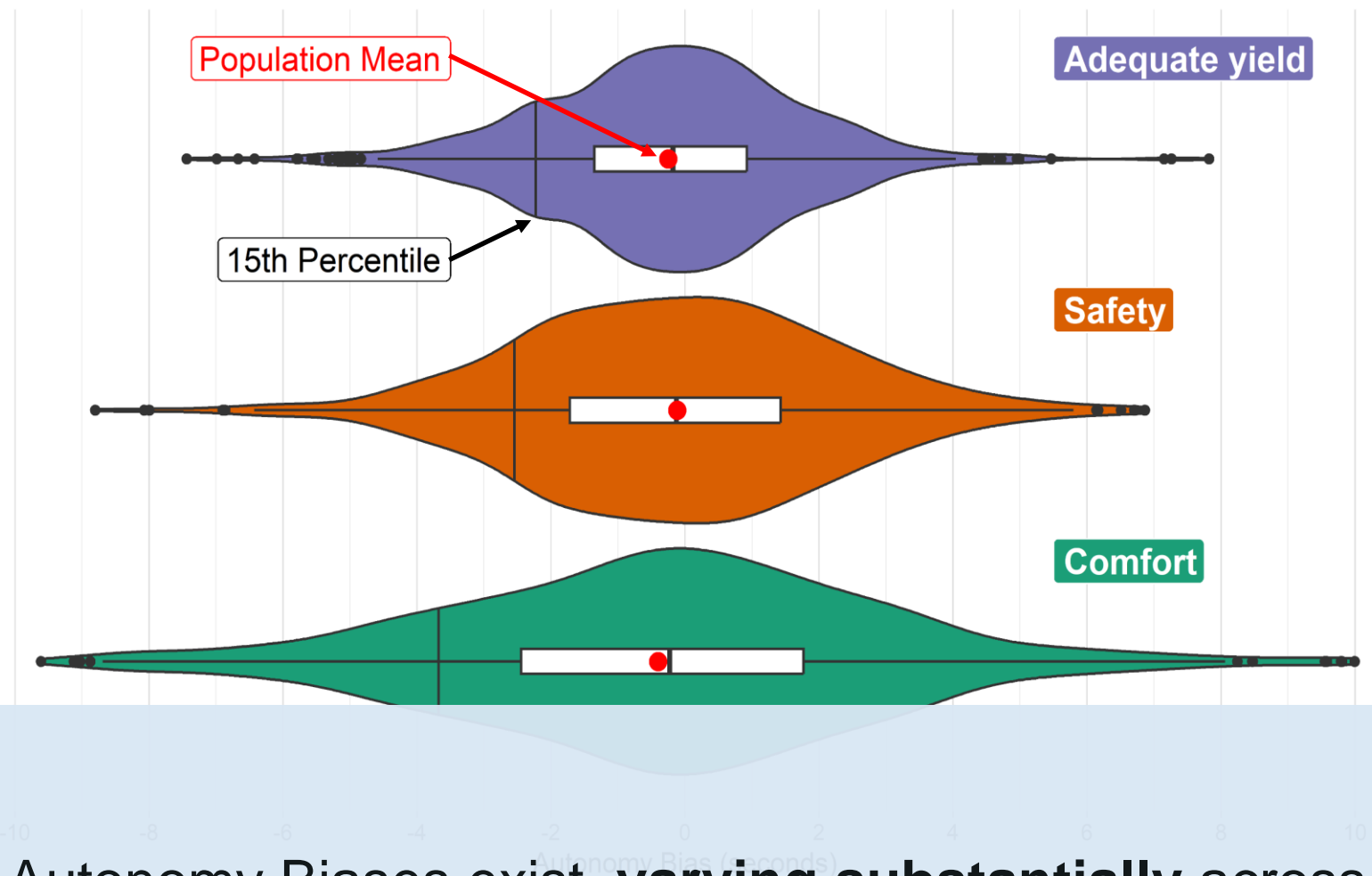
Three indicators of Autonomy Bias expressed in terms of equivalent passing time (change in time gap between road users that has an equivalent effect on adequate yield, safety, and comfort perceptions)



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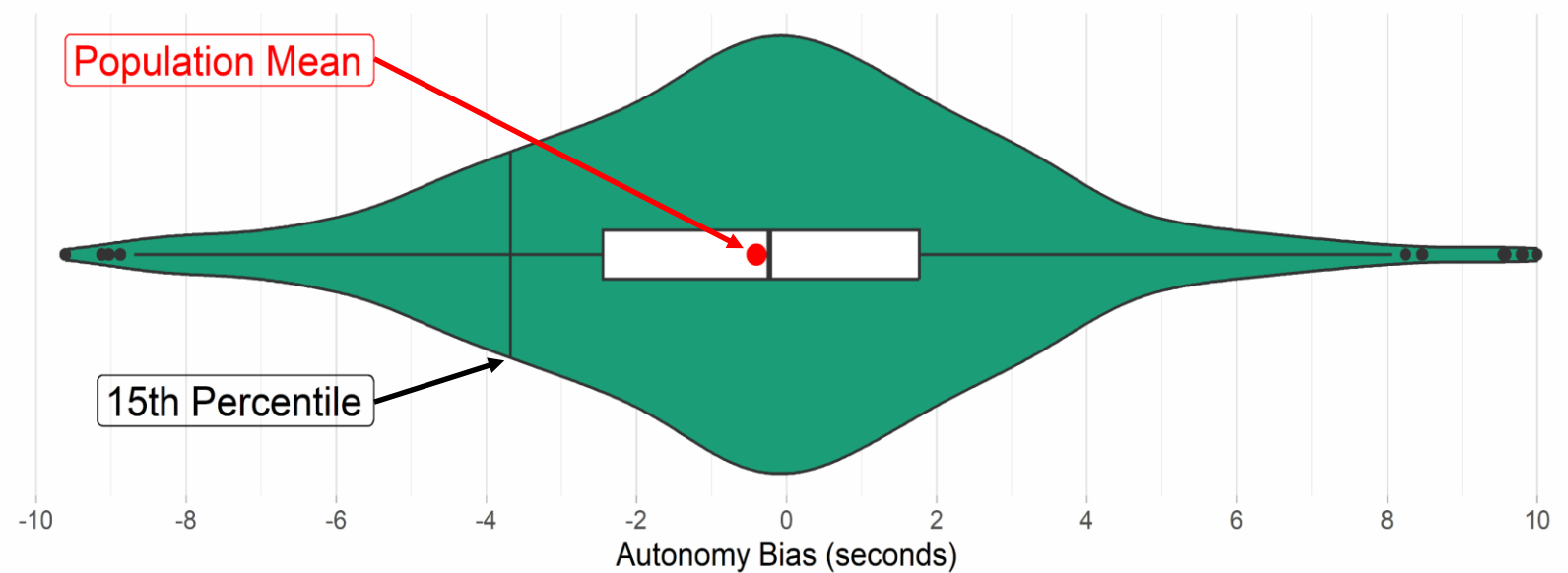
Finding: Both **positive** and **negative** Autonomy Biases exist, **varying substantially** across BC residents, who have a small but significant **negative mean bias**

RESULTS AND FINDINGS

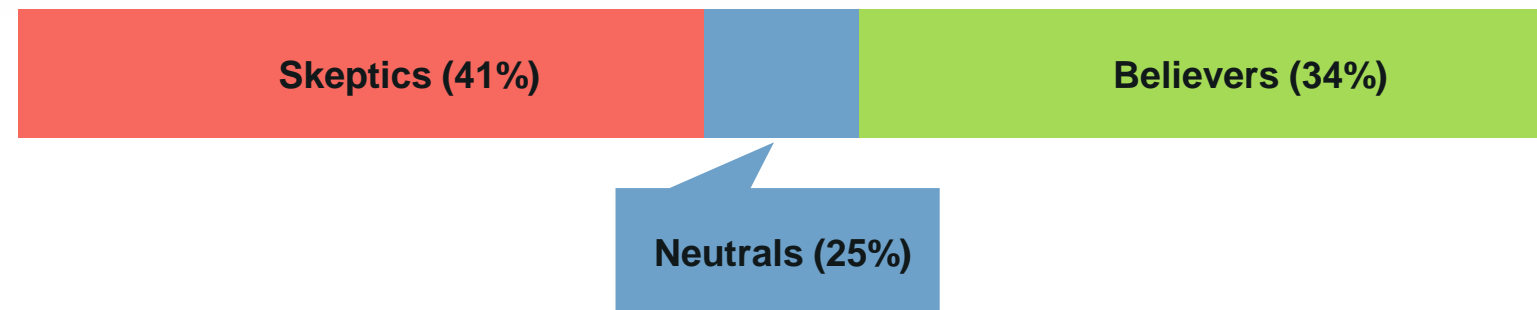
Divided BC population into 3 groups based on Autonomy Bias (comfort):

- **Skeptics:** People who have a bias *against* SDVs (negative Autonomy Bias)
- **Neutrals:** People who have *no* bias towards SDVs
- **Believers:** People who have a bias *in favour* of SDVs (positive Autonomy Bias)

Autonomy Bias expressed in terms of equivalent passing time
(change in time gap between road users that has an equivalent effect on comfort perceptions)



Negative values indicate SDVs needing more passing time than HDVs to obtain the same level of comfort as HDVs

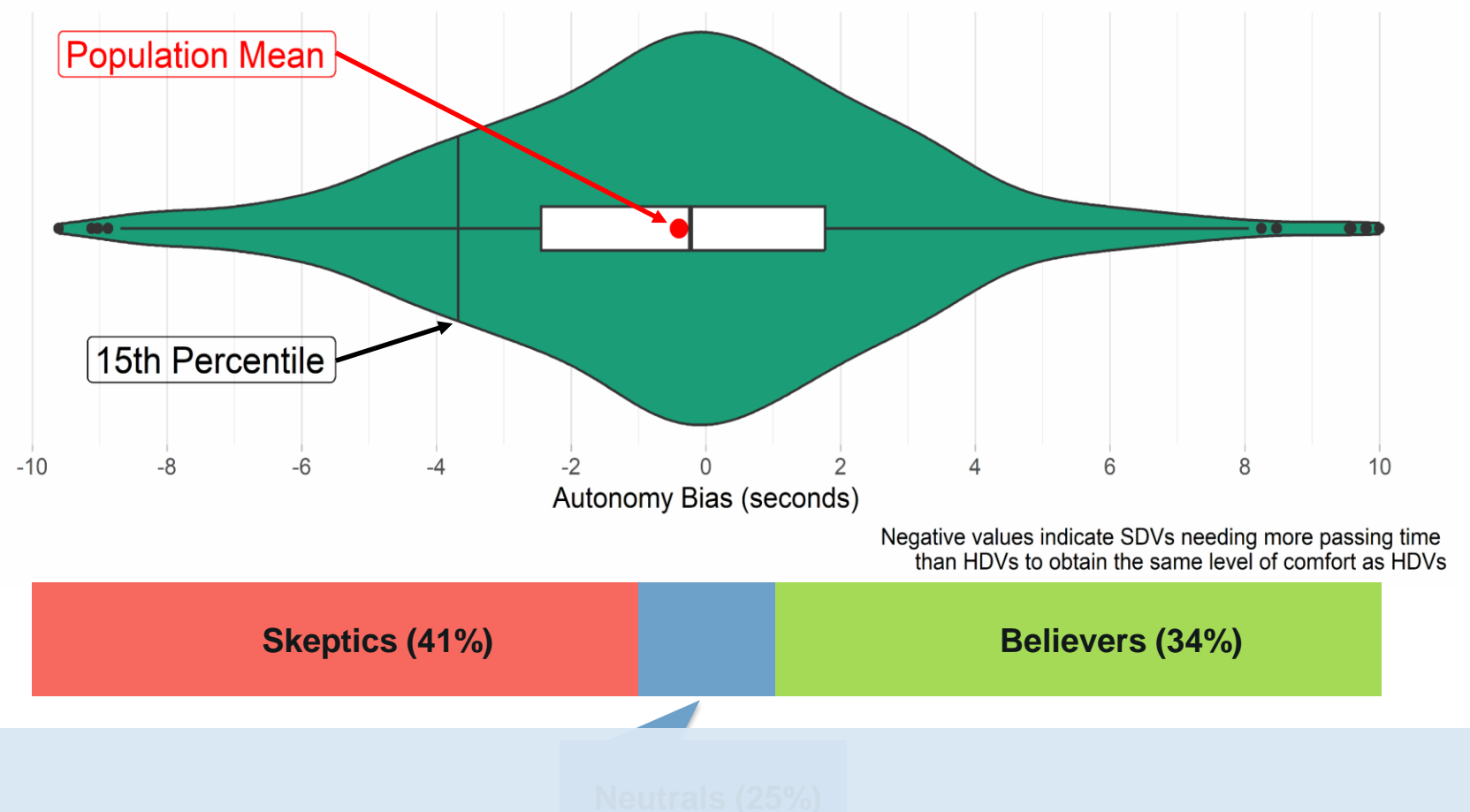


RESULTS AND FINDINGS

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- **Believers:** People who have a bias *in favour* of SDVs (positive Autonomy Bias)

Autonomy Bias expressed in terms of equivalent passing time
(change in time gap between road users that has an equivalent effect on comfort perceptions)



Finding: **More people in the population (41%) are Skeptics**, compared to 34% Believers; a substantial portion (25%) are Neutrals (their bias is smaller than 1 second equivalent passing time)

RESULTS AND FINDINGS

- People who are anxious about SDV development
 - People who are uncomfortable embracing new technology
 - People who are cis-men
- more likely to have a bias *against* SDVs

This negative bias would tend to degrade their walking experience

What increases **Autonomy Bias**?
(i.e., makes SDVs more favourable)

Increasing **enthusiasm** about SDVs

Increasing **comfort** in embracing technology

Not a **cis-man**



RESULTS AND FINDINGS

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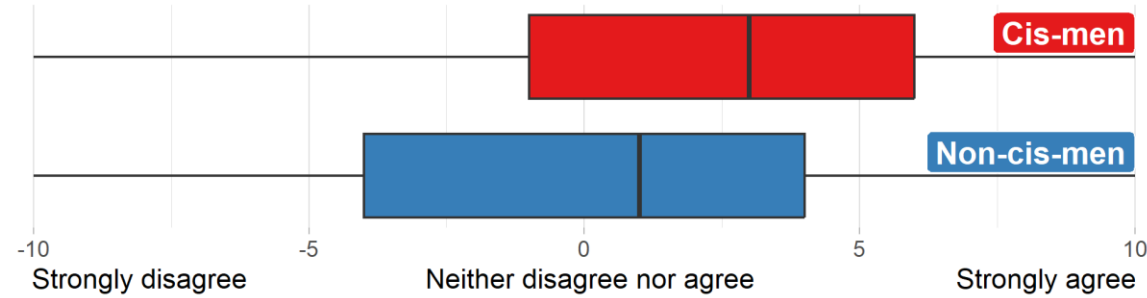
Increasing **comfort** in embracing technology

Not a **cis-man**

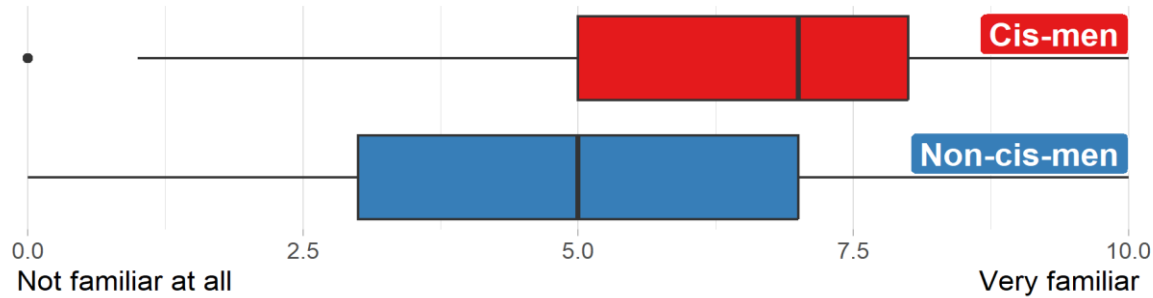
Finding: Autonomy Bias varies systematically with **gender**, **tech savviness**, and affective response to SDV (**level of anxiety or enthusiasm**), but not with other socio-demographic factors or travel habits.

INTERESTINGLY, CIS-MEN ARE MORE LIKELY TO HAVE A NEGATIVE AUTONOMY BIAS YET REPORT POSITIVE ATTITUDES TOWARDS SDVs

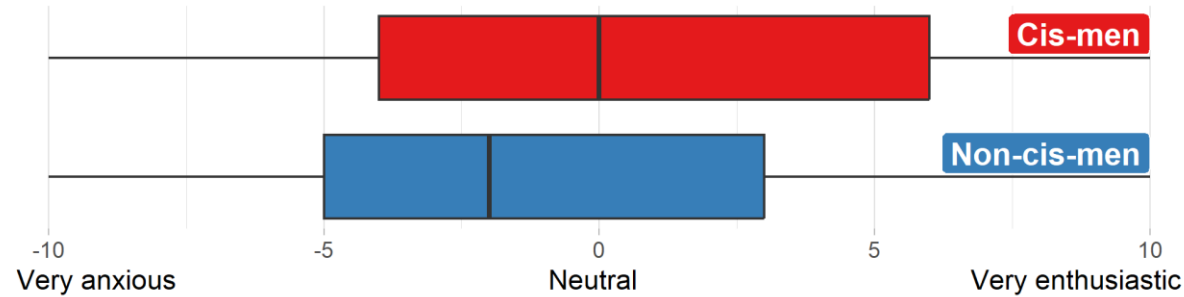
I tend to embrace technology before most other people do.



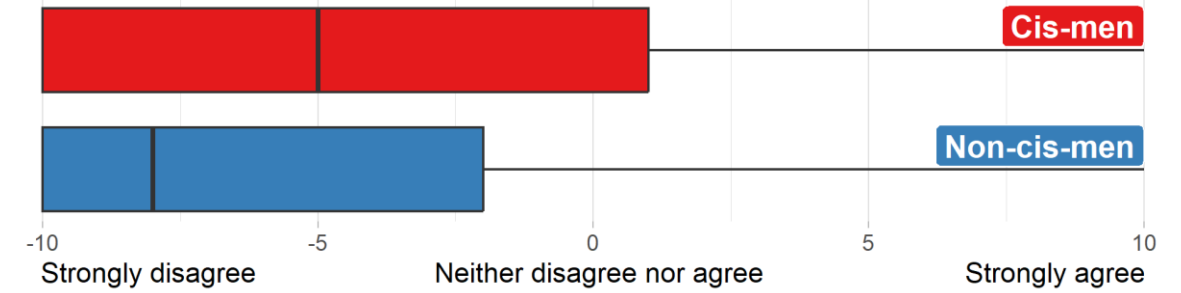
How familiar are you with the development of SDVs?



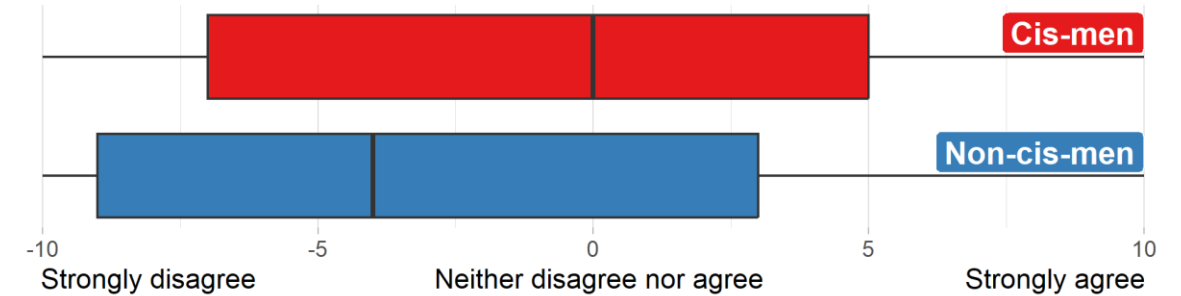
When you think about the development of SDVs, you feel...



I plan to purchase a SDV when they are available.

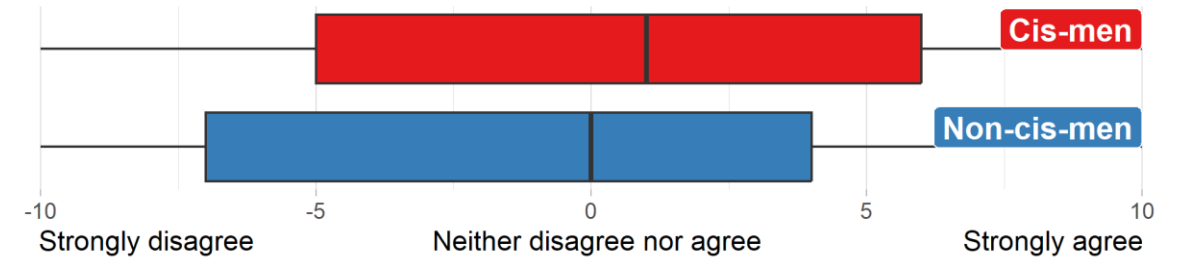


I plan to ride in shared SDVs when they are available (e.g., as a taxi or shuttle).



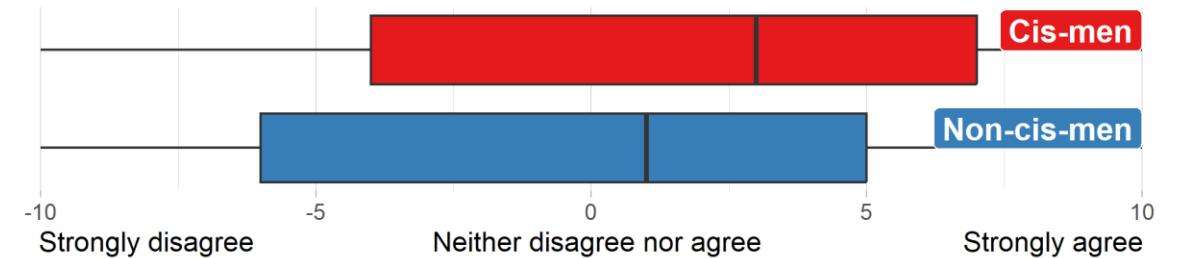
I support policies...

Allowing privately-owned SDVs to operate on public roads.



I support policies...

Allowing shared SDVs (e.g., taxis or shuttles) to operate on public roads.



Finding: Observed and self-reported relationships between gender and SDVs are inconsistent

RESULTS AND FINDINGS

Allowing shared SDVs (e.g., taxis or shuttles) to operate on public roads

55% of population agrees

Allowing privately-owned SDVs to operate on public roads

48%

Allowing SDVs to travel at the same speed as HDVs

42%

Allowing SDVs to enter pedestrian priority areas, such as near schools

28%

Allowing SDVs to operate without a person in the driver's seat

11%

Allowing SDVs to operate without being clearly identified to other road users

8%

Around half of the population supports general policies — allowing private or shared SDVs to operate on public roads

There is strong support for specific SDV restrictions — a large majority of population does not favour SDVs to operate near pedestrian areas, without a "driver", or without clear identification



RESULTS AND FINDINGS

Allowing shared SDVs (e.g., taxis or shuttles) to operate on public roads

55% of population agrees

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Around half of the population supports general policies — allowing private or shared SDVs to operate on public roads

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28%

Findings: Similar to Autonomy Bias, **BC residents are close to evenly split** on whether they support two general SDV policies: allowing privately-owned or shared SDVs to operate on public roads

In contrast to support for general policies, **there is strong support for specific SDV restrictions** – a large majority of BC residents want SDVs to be clearly identified, have a human “driver” present, and be restricted from entering pedestrian dominated areas such as near schools



RESULTS

Finding: **Being enthusiastic about SDVs** determines SDV policy support

SDV policies
Allowing shared SDVs (e.g., taxis or shuttles) to operate on public roads
Allowing privately-owned SDVs to operate on public roads
Allowing SDVs to travel at the same speed as HDVs
Allowing SDVs to enter pedestrian priority areas, such as near schools
Allowing SDVs to operate without a person in the driver's seat
Allowing SDVs to operate without being clearly identified to other road users



Being enthusiastic about SDVs Being younger than 40 Increasing Autonomy Bias Driving an automobile rarely
Being enthusiastic about SDVs Riding an automobile often Being younger than 40
Being enthusiastic about SDVs Increasing Autonomy Bias Living outside lower mainland
Being enthusiastic about SDVs Driving an automobile often
Being enthusiastic about SDVs Being a cis-man Being white
Being enthusiastic about SDVs Living outside lower mainland

RESULTS

Finding: SDV-related factors – **being enthusiastic about SDVs** and having a more **positive Autonomy Bias** – determine SDV policy support most consistently

SDV policies
Allowing shared SDVs (e.g., taxis or shuttles) to operate on public roads
Allowing privately-owned SDVs to operate on public roads
Allowing SDVs to travel at the same speed as HDVs
Allowing SDVs to enter pedestrian priority areas, such as near schools
Allowing SDVs to operate without a person in the driver's seat
Allowing SDVs to operate without being clearly identified to other road users

Factors increasing policy support

Being enthusiastic about SDVs	Being tech savvy	
Being younger than 40	Increasing Autonomy Bias	Driving an automobile rarely
Being enthusiastic about SDVs	Being tech savvy	
Riding an automobile often	Being younger than 40	
Being enthusiastic about SDVs	Increasing Autonomy Bias	Living outside lower mainland
Being enthusiastic about SDVs	Increasing Autonomy Bias	
Driving an automobile often		
Being enthusiastic about SDVs	Being a cis-man	Being white
Being enthusiastic about SDVs	Living outside lower mainland	

RESULTS

Findings: But **socio-demographic factors** still persist

- **Older people** are less likely to favour shared SDVs
- **People of colour and non-cis-men** want to restrict SDVs from operating without a “driver”
- **People with less auto mobility** want to restrict SDVs from going into pedestrian priority areas

SDV policies

Allowing shared SDVs (e.g., taxis or shuttles) to operate on public roads

Allowing privately-owned SDVs to operate on public roads

Allowing SDVs to travel at the same speed as HDVs

Allowing SDVs to enter pedestrian priority areas, such as near schools

Allowing SDVs to operate without a person in the driver’s seat

Allowing SDVs to operate without being clearly identified to other road users

Factors increasing policy support

Being enthusiastic about SDVs Being tech savvy

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Being enthusiastic about SDVs Increasing Autonomy Bias

Driving an automobile often

Being enthusiastic about SDVs

Being a cis-man

Being white

Being enthusiastic about SDVs

Living outside lower mainland

RECOMMENDATIONS



RECOMMENDATIONS (A CAUTIOUS, TIERED APPROACH)

- We recommend a **cautious, tiered approach** to SDV introduction, starting with pilot testing.
- Testing should be conducted with **specific restrictions** to address the concerns of BC residents.
- This recommendation is based on:
 - the demonstrated potential for SDV to **both positively and negatively** impact perceptions of safety and comfort for pedestrians
 - the **divided support** for SDV introduction
 - the **strong support** for SDV restrictions



RECOMMENDATIONS (GUIDELINES FOR PILOT TESTING)

- Introduction should begin with **restrictive pilot testing**, which will allow road users to experience and observe interactions with SDVs in more limited and controlled settings.
- **SDVs should be programmed to operate more conservatively** than HDVs around pedestrians to ensure comfort
 - SDVs must allow 3.7 seconds additional passing time at crosswalks than typical HDVs to offset the Autonomy Bias of 85% of the population.
- SDVs should be required to have **external communication features** that, at the least, inform other road users that the motor vehicle they are interacting with is self-driven.
- SDVs should be required to have **a person in the driver's seat** to take control of the vehicle in emergencies, and provide interacting road users a familiar human presence with an oversight function.
- **SDVs should not be initially tested in pedestrian priority areas** such as near schools.



RECOMMENDATIONS (PILOT TESTING → INTRODUCTION)

- Opportunities should be provided to the public to **gain knowledge about SDV** technology, operations, and performance.
- Familiarity with SDVs from SDV experience (during pilot testing) and gaining knowledge leads to **more enthusiasm**, which in turn leads to **favourable perceptions** of SDVs (i.e., positive Autonomy Bias) and **increases support** for “pro-SDV” policies.
- Public **feedback should be sought** through surveys, interviews, and focus groups to evaluate the level of comfort and policy support of road users before, during, and after pilot testing of SDVs.
- If the perceptions of a reasonably large proportion of the public **shift toward comfort**, then SDV **restrictions can be eased** accordingly





THE UNIVERSITY OF BRITISH COLUMBIA

Thank you!

For any questions, contact Dr. Alex Bigazzi at abigazzi@ubc.civil.ca

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We would also like to acknowledge the time and valuable input from all the survey participants.