Perceived Safety and Comfort of Pedestrian Interactions with Self-driving Vehicles

Recommendations for responsible introduction of self-driving vehicles

Executive summary prepared for TransLink

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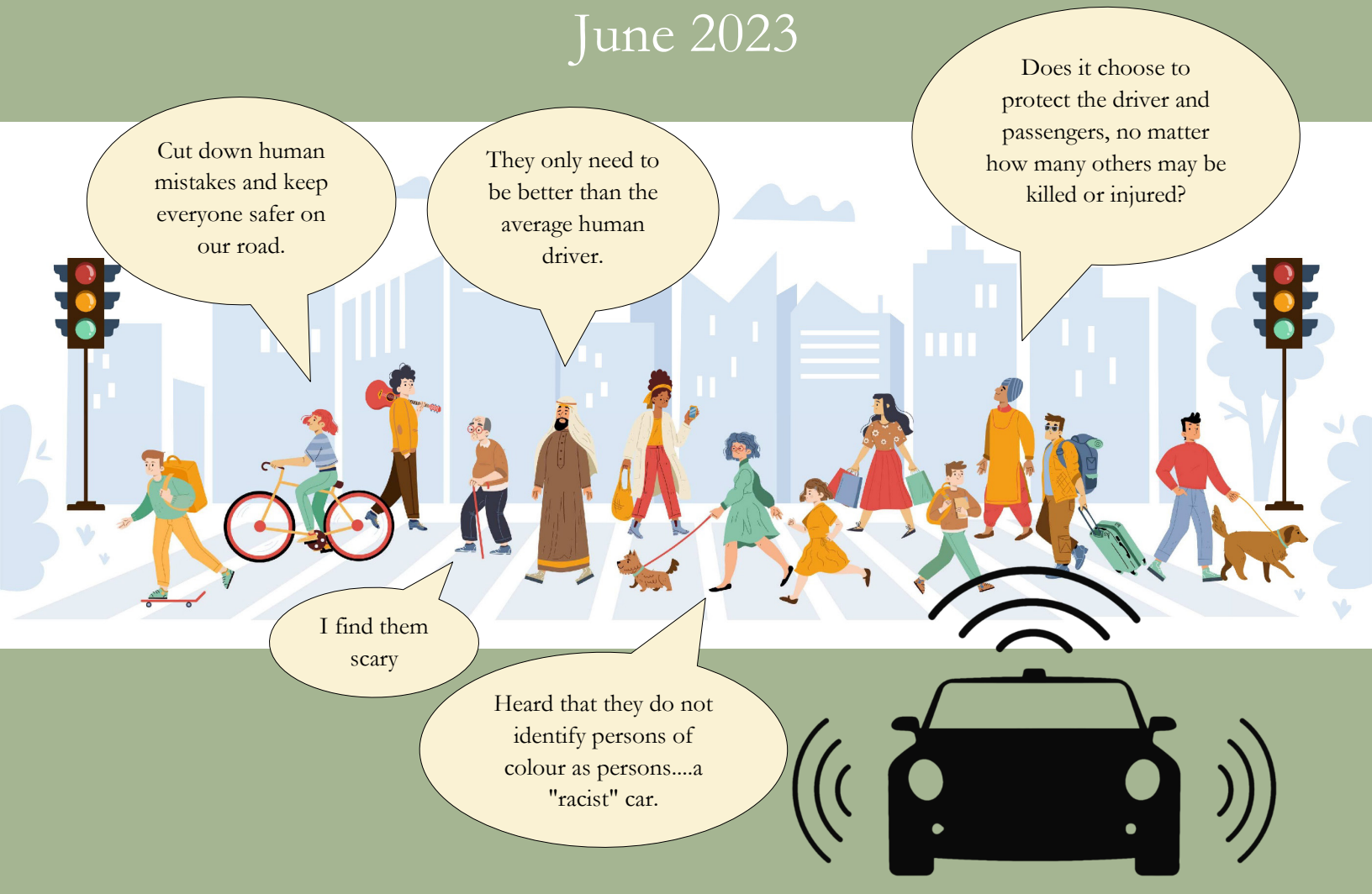

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research on active transportation
react
https://reactlab.civil.ubc.ca/

ICTA
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https://citylabbcn.org/

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EXECUTIVE SUMMARY

Project background

To counter some of the negative environmental, social, and economic impacts of our long-existing reliance on motor vehicles, many urban areas in Canada and throughout the world are promoting active modes of travel such as walking and cycling. For example, the Regional Transportation Strategy for Metro Vancouver (Transport 2050) has set a goal of at least half of all passenger trips to be made using active modes and transit by 2050 (*1*). Transport 2050 also emphasizes the importance of active mode users' perceived safety and comfort to realize that mode share goal: "If people enjoy their transportation experience, they are more likely to travel. Walking, biking, rolling and using transit should be inviting and enjoyable experiences. A key part of this is feeling comfortable, safe, and secure when travelling" (*2*).

While promoting active modes of travel, public agencies are also planning for the introduction of self-driving vehicles (SDVs) into existing transportation systems, as SDVs have the potential to improve the safety, efficiency, and accessibility of our transportation systems. But SDVs should be introduced and integrated responsibly; SDV technology should be trustworthy and SDVs should support active modes of travel rather than degrade their experience.

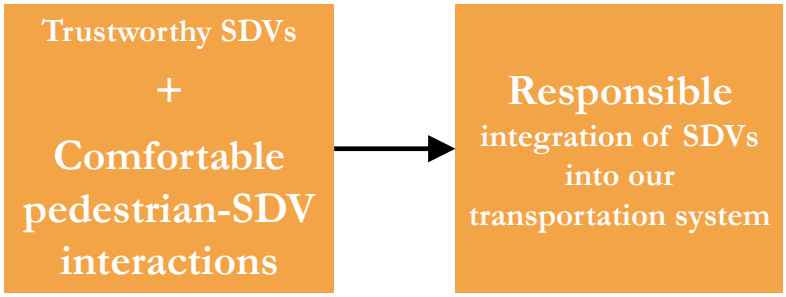

Figure 1. Integrate SDVs responsibly; SDVs should support walkability rather than degrade the walking experience

Considerable research has focused on the operation and technological reliability of SDVs, which is only part of the process of responsible introduction and integration. Another crucial aspect is ensuring the comfort of active travellers, including the quality of pedestrian-SDV interactions. While SDVs may differ in a number of ways from HDVs (human-driven vehicles), the essential defining characteristic is that vehicle control is ceded from a human to a computer. This fundamental difference, along with other changes in vehicle operation or appearance, will likely influence perceptions of safety and comfort for active travellers. Pedestrian interactions with SDV are more complex and challenging than HDV interactions because, among other reasons, pedestrian-driver communications are disrupted. Pedestrians may find it more challenging to both communicate their intentions and infer the intentions of SDVs. Moreover, because perceptions of safety vary systematically across the population, introducing SDVs may disproportionally affect comfort for certain groups of people.

The goal of this study is to inform strategies for the responsible introduction of SDVs in a way that does not degrade the walking experience. We seek to understand how a diverse and representative array of people perceive interactions between pedestrians and SDVs, in contrast to today's HDVs, and how these perceptions relate to policy support for efforts to integrate and regulate SDVs.

This study investigates three main research questions (RQ):

RQ1. 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")?
RQ2. Does the Autonomy Bias vary systematically within the population (e.g. with age, gender, ethnicity, travel habits, and so on)?
RQ3. Which personal attributes, including Autonomy Bias, determine support for various SDV policies?

Overview of study methods

The study methods are summarized in Figure 2. We developed a novel deception-based experiment within a web survey[1] to measure the Autonomy Bias (i.e., examine if people perceive pedestrian interactions with SDVs as more or less comfortable and safe than interactions with HDVs, controlling for all other differences). In the experiment, all survey participants watched the same 8 video clips of pedestrian-vehicle interactions at crosswalks. We identified a random half of the interacting vehicles as SDVs, and the other half as HDVs (all vehicles were in fact HDV). Each participant assessed the comfort and safety of those interactions and we developed statistical models to quantify each participant's Autonomy Bias. This unique experimental design allowed us to isolate the bias effect of vehicle autonomy on comfort and safety perceptions (RQ1), which we report as the additional seconds of passing time that would generate an equivalent effect on perceptions of safety and comfort. To address RQ2, we also collected data on participants' socio-demographics, travel habits, and attitudes toward technology and SDVs. We specified a structural equation model (SEM) with Autonomy Bias as the dependent variable and personal attributes and attitudes as independent variables. To address RQ3, we specified another SEM with SDV policies as the dependent variables and personal attributes, attitudes, and Autonomy Bias as independent variables.

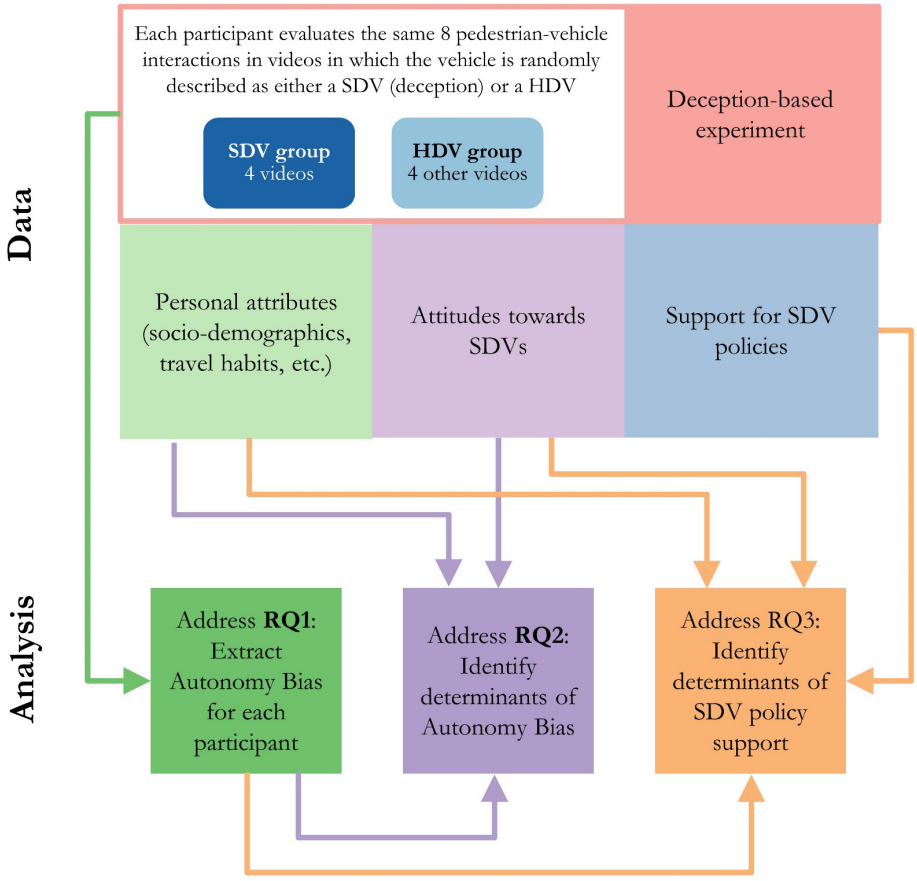

Figure 2. Study methods

[1] The survey was only advertised in BC. Raw data had 1557 participants, with a final sample of 1133 participants after filtering.

Key findings

1. Both positive and negative Autonomy Biases exist, varying substantially across BC residents, who have a small but significant negative mean bias (Figure 3). More of the population (41%) has a negative Autonomy Bias (i.e., a bias *against* SDVs), compared to 34% having a positive bias; a substantial portion (25%) has no substantial bias (smaller than 1 second equivalent passing time).

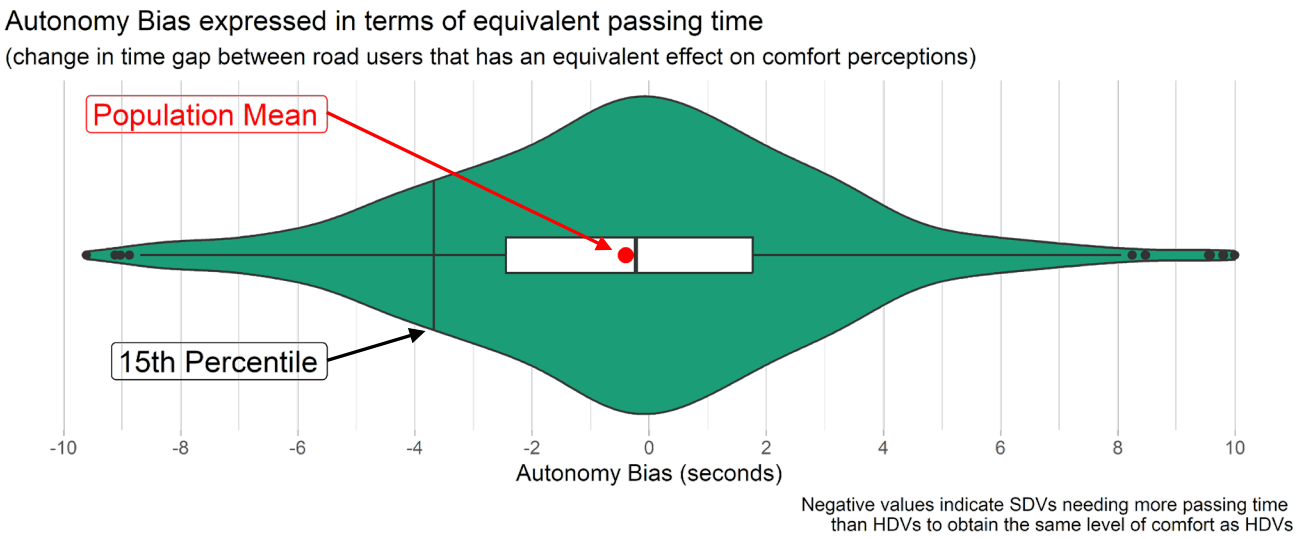

Figure 3. Autonomy Bias of survey participants, weighted to represent the BC population

2. 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. People who are anxious about SDV technology or are uncomfortable embracing new technology (and cis-men) are more likely to have a bias *against* SDVs, which would tend to degrade their walking experience.
3. 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 (Figure 4).
4. In contrast, 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 (Figure 4).
5. Even though two SDV-related factors – being enthusiastic about SDVs and having a more positive Autonomy Bias – determine SDV policy support most consistently, socio-demographic factors persist. A few subgroups of the population (including equity-seeking groups) give less policy support; 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", and people with less auto mobility want to restrict SDVs from going into pedestrian priority areas.

> I am still unsure of the technologies. I feel a person needs to be available in the car to take control of the vehicle in case of emergencies however I also see self driven cars might be a help to those with disabilities. I haven't clarified these opinions yet.

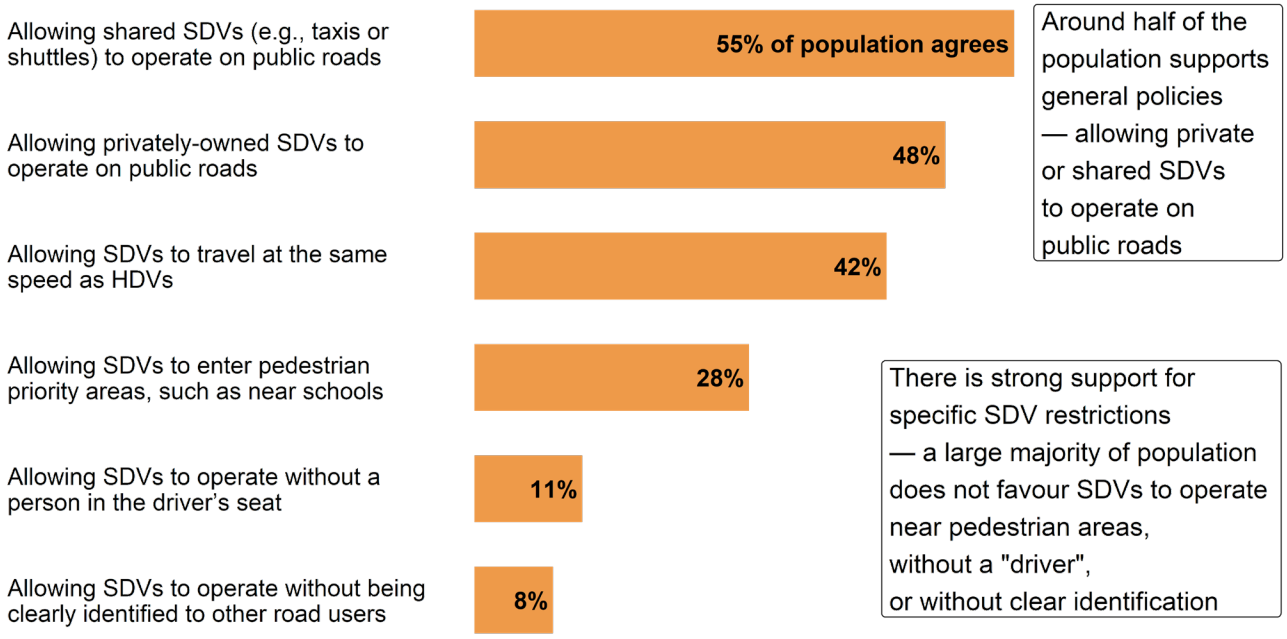

Figure 4. Level of support for self-driving vehicle policies

Recommendations

Considering the demonstrated potential for SDV to both positively and negatively impact perceptions of safety and comfort for pedestrians in BC, the divided support for SDV introduction, and the strong support for SDV restrictions, we recommend a **cautious, tiered approach to SDV introduction**, with specific restrictions to address the concerns of BC residents.

> I think I [would] start introducing more self-driving vehicles very cautiously and with quite restricted conditions before opening the roads to that technology. Just start slow to really test and then adjust.

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. This study shows that introducing SDVs without specific restrictions might disproportionately impact the walking experience of equity-seeking groups.

- To ensure the comfort of a large proportion of the BC population, **SDVs should be programmed to operate more conservatively** than HDVs around pedestrians and other vulnerable road users. SDVs must allow 3.7 seconds additional passing time at crosswalks than typical HDVs to offset the Autonomy Bias of 85% of the population ("15th percentile" in Figure 3).

- 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.

In this initial phase, opportunities should be provided to the public to gain knowledge about SDV technology, operations, and performance. This study shows that familiarity with SDVs improves self-reported affective response to SDVs (i.e., leads to more enthusiasm), which in turn improves Autonomy Bias (i.e., leads to favourable perceptions of SDVs) and increases support for SDV policies (i.e., easing restrictions and allowing SDVs to operate on public roads). Public feedback should be sought through surveys, interviews, and focus groups to record and 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.