Self-driving Cars & Data Collection

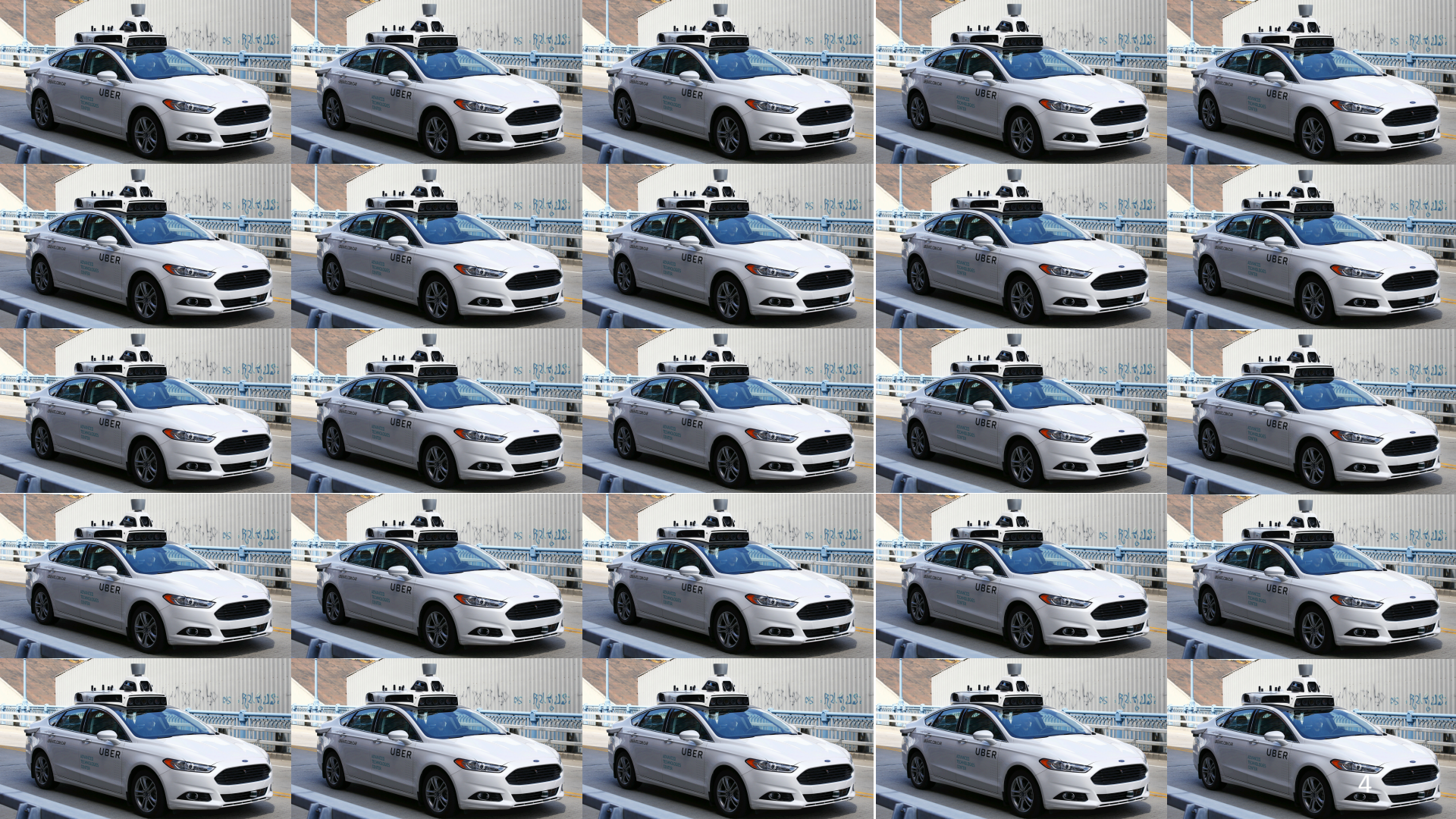
Privacy Perceptions of Networked Autonomous Vehicles

Cara Bloom, Joshua Tan, Javed Ramjohn, Lujo Bauer

Carnegie Mellon University


UBERATC.COM/CAR
UBER
ADVANCED
TECHNOLOGIES
CENTER


UBERATC.COM/CAR
UBER
ADVANCED
TECHNOLOGIES
CENTER


UBER

Why networked autonomous vehicle (AV) privacy?

Why networked AV privacy?

1. Data collection capabilities

Why networked AV privacy?

1. Data collection capabilities
2. Operated by a private company

Why networked AV privacy?

1. Data collection capabilities
2. Operated by a private company
3. Collection of physical information in public

Research Goal

Discover what is ‘reasonable’ data collection and use for autonomous vehicle (AV) fleets

Research Goal

1. What do people think AV fleets are capable of?

Research Goal

1. What do people think AV fleets are capable of?
2. How comfortable are people with AV fleet capabilities?

Research Goal

1. What do people think AV fleets are capable of?
2. How comfortable are people with AV fleet capabilities?
3. How much effort would people expend to opt out?

Up Next

1. Study Design
2. Findings
3. Policy Applications

Study Design

- Exploratory online survey

Study Design

- Exploratory online survey
- Privacy primed & unprimed groups

Privacy Priming Scenarios

Primary Uses

Secondary Uses

Privacy Priming Scenarios

Primary Uses

Necessary for autonomous navigation

Secondary Uses

Privacy Priming Scenarios

	Image Capture	Aggregation & Storage	Specific Incident Analysis	Continuous Analysis
Primary Uses				
Secondary Uses				

Privacy Priming Scenarios

Primary Uses	Image Capture	Aggregation & Storage	Specific Incident Analysis	Continuous Analysis
Secondary Uses	Non-necessary. Can be achieved with same sensors.			

Privacy Priming Scenarios

Primary Uses

Image Capture	Aggregation & Storage	Specific Incident Analysis	Continuous Analysis

Secondary Uses

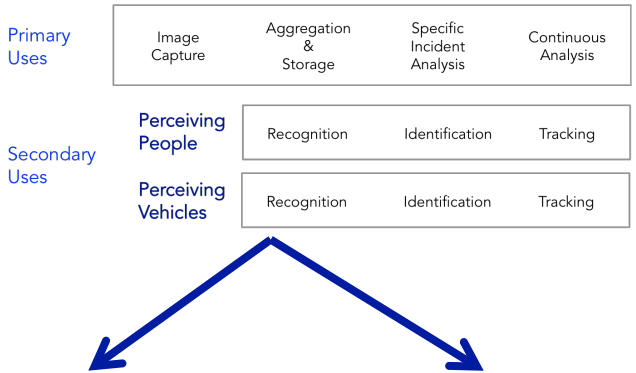
Perceiving People

Recognition	Identification	Tracking

Privacy Priming Scenarios

Primary Uses	Image Capture	Aggregation & Storage	Specific Incident Analysis	Continuous Analysis
Secondary Uses – Perceiving People	Recognition	Identification	Tracking	
Secondary Uses – Perceiving Vehicles	Recognition	Identification	Tracking	

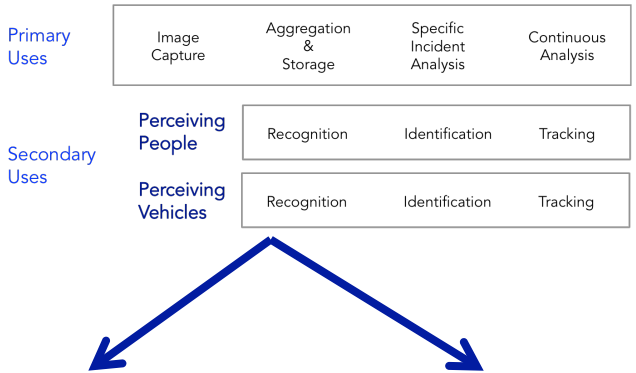
Survey Questionnaire



Likelihood of currently occurring

Comfort if currently occurring

Survey Questionnaire



Likelihood of currently occurring

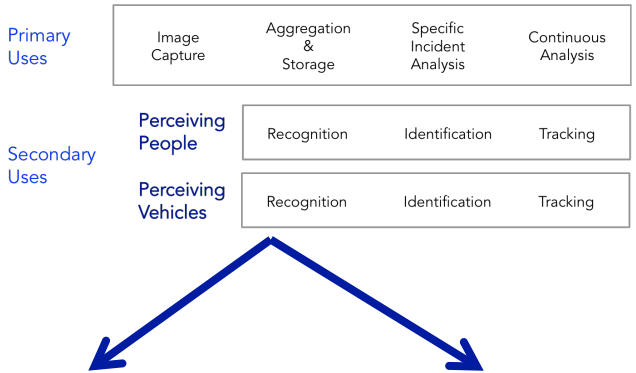
Comfort if currently occurring

General AV questions

Effort to opt out

Bias against Uber & demographics

Survey Questionnaire



Likelihood of currently occurring

Comfort if currently occurring

General AV questions

Effort to opt out

Bias against Uber & demographics

Seen by Primed Group

Survey Questionnaire

Seen by **Unprimed** Group

Likelihood of currently occurring

Comfort if currently occurring

General AV questions

Effort to opt out

Bias against Uber & demographics

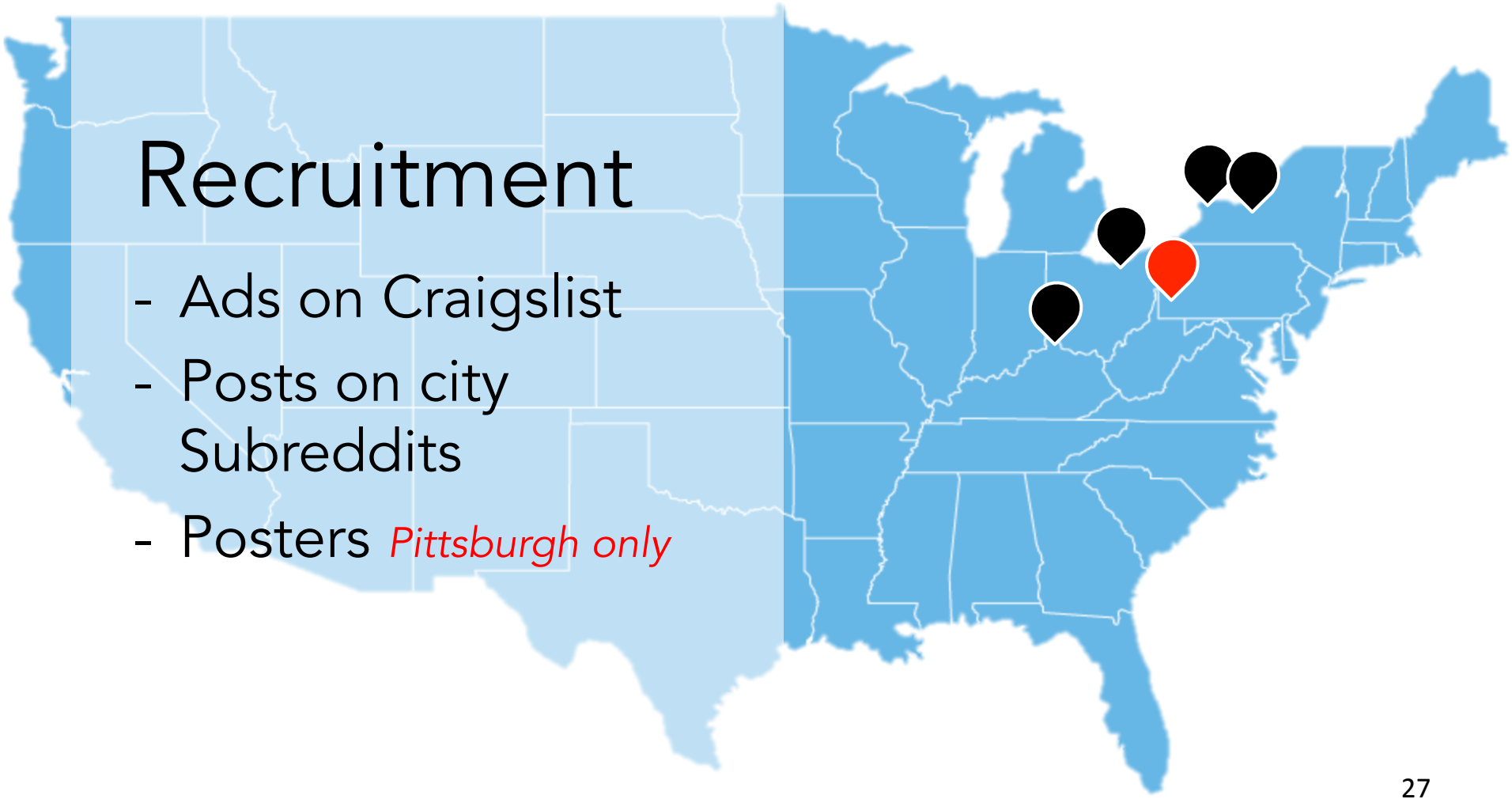
Seen by Primed Group

Study Design

- Exploratory online survey
- Privacy primed & unprimed groups
- Pittsburgh & four similar cities

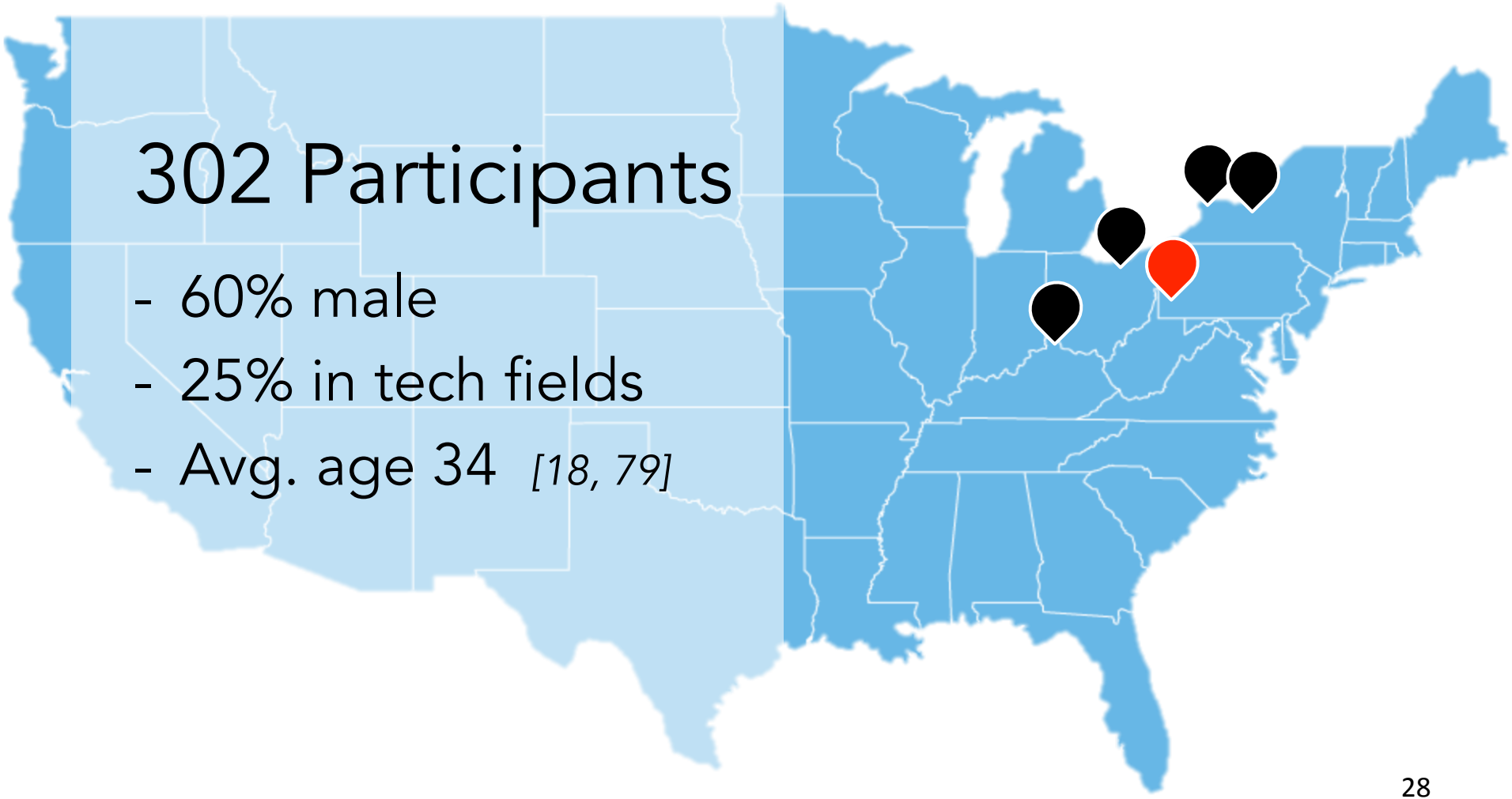
Recruitment

- Ads on Craigslist
- Posts on city Subreddits
- Posters *Pittsburgh only*



302 Participants

- 60% male
- 25% in tech fields
- Avg. age 34 *[18, 79]*



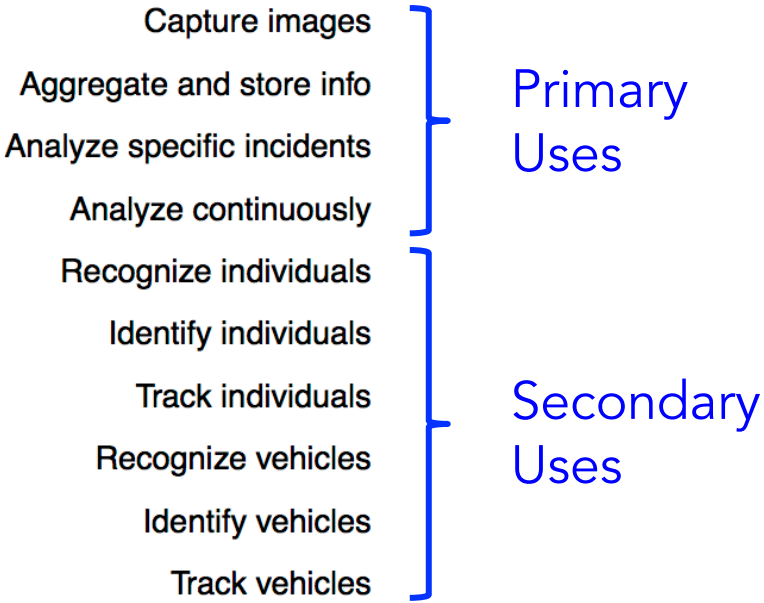
Question:

What do people think networked fleets of autonomous vehicles are capable of?

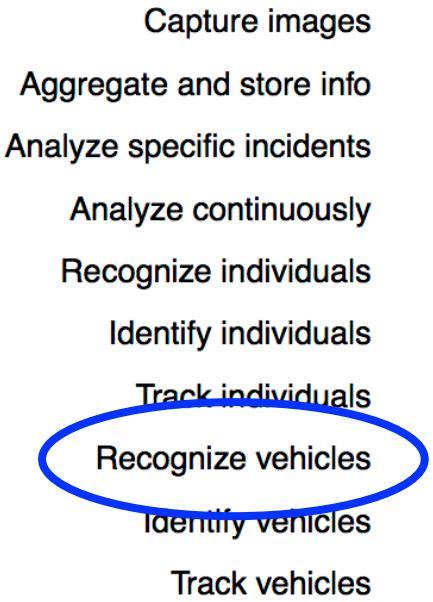
Privacy Questions

Primary Uses	Image Capture	Aggregation & Storage	Specific Incident Analysis	Continuous Analysis
Secondary Uses – Perceiving People	Recognition	Identification	Tracking	
Secondary Uses – Perceiving Vehicles	Recognition	Identification	Tracking	

Likelihood of Technical Capability

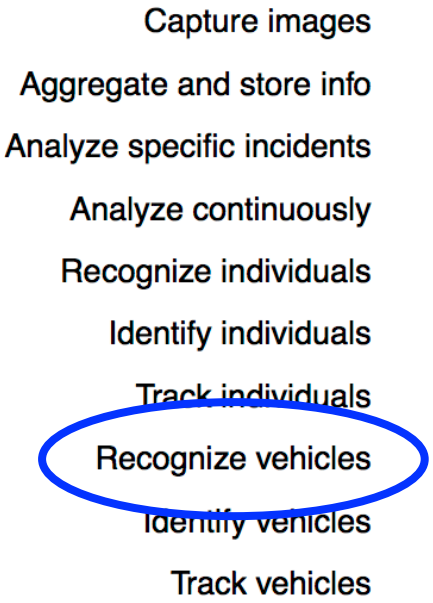


Likelihood of Technical Capability



How likely do you think this scenario is to be happening now?

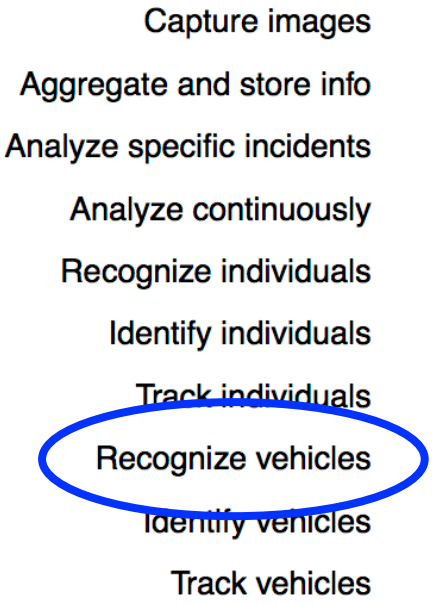
Likelihood of Technical Capability



How likely do you think this scenario is to be happening now?

Q13. A self-driving car recognizes a vehicle that has been seen by another self-driving car in the fleet

Likelihood of Technical Capability

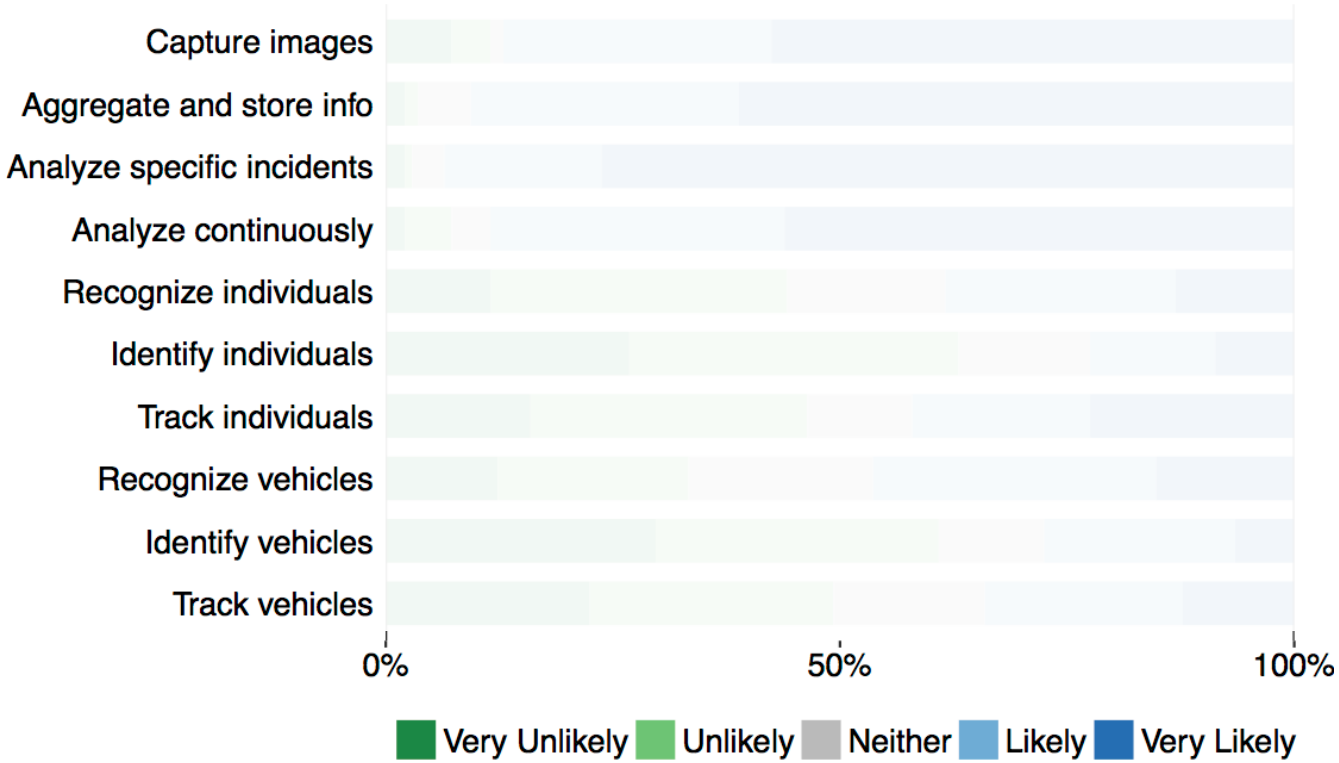


How likely do you think this scenario is to be happening now?

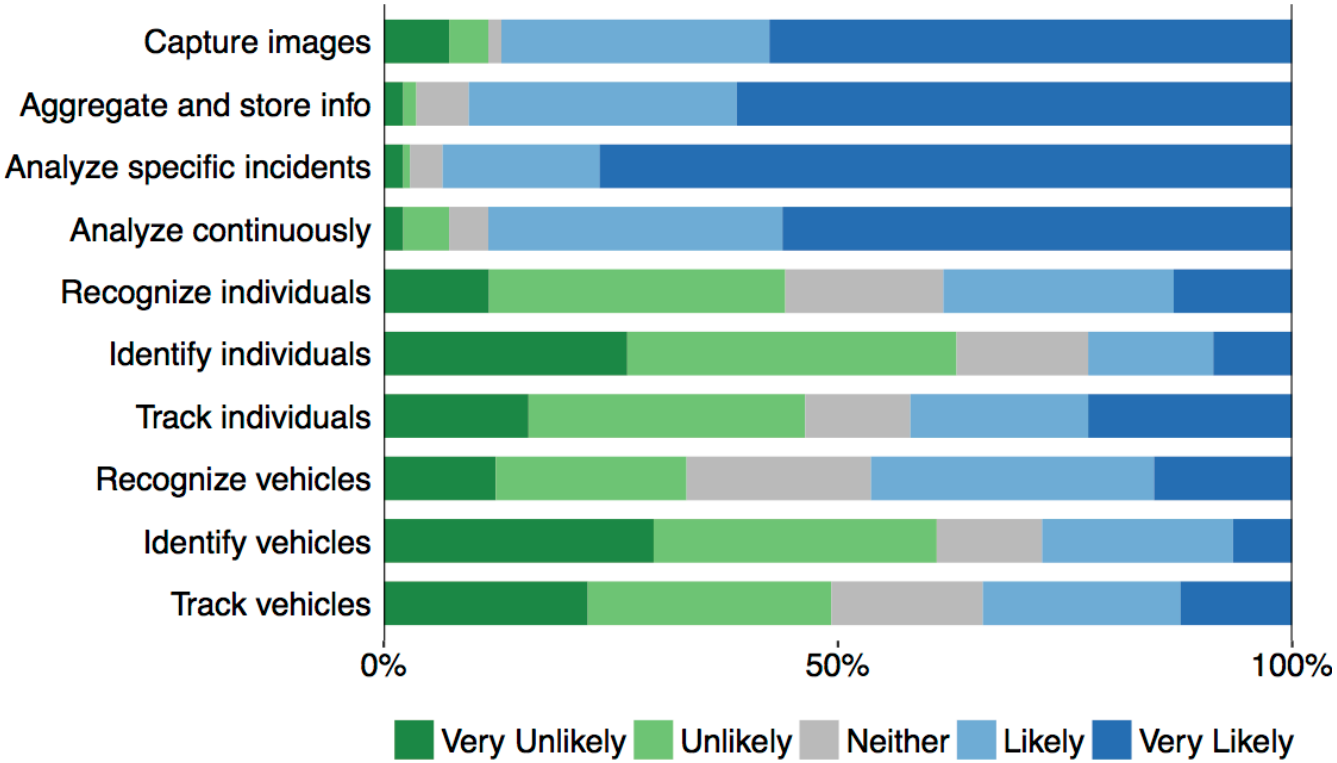
Q13. A self-driving car recognizes a vehicle that has been seen by another self-driving car in the fleet

For example: Uber knows that different self-driving cars encountered the same vehicle on different days, but does not know who owns the vehicle

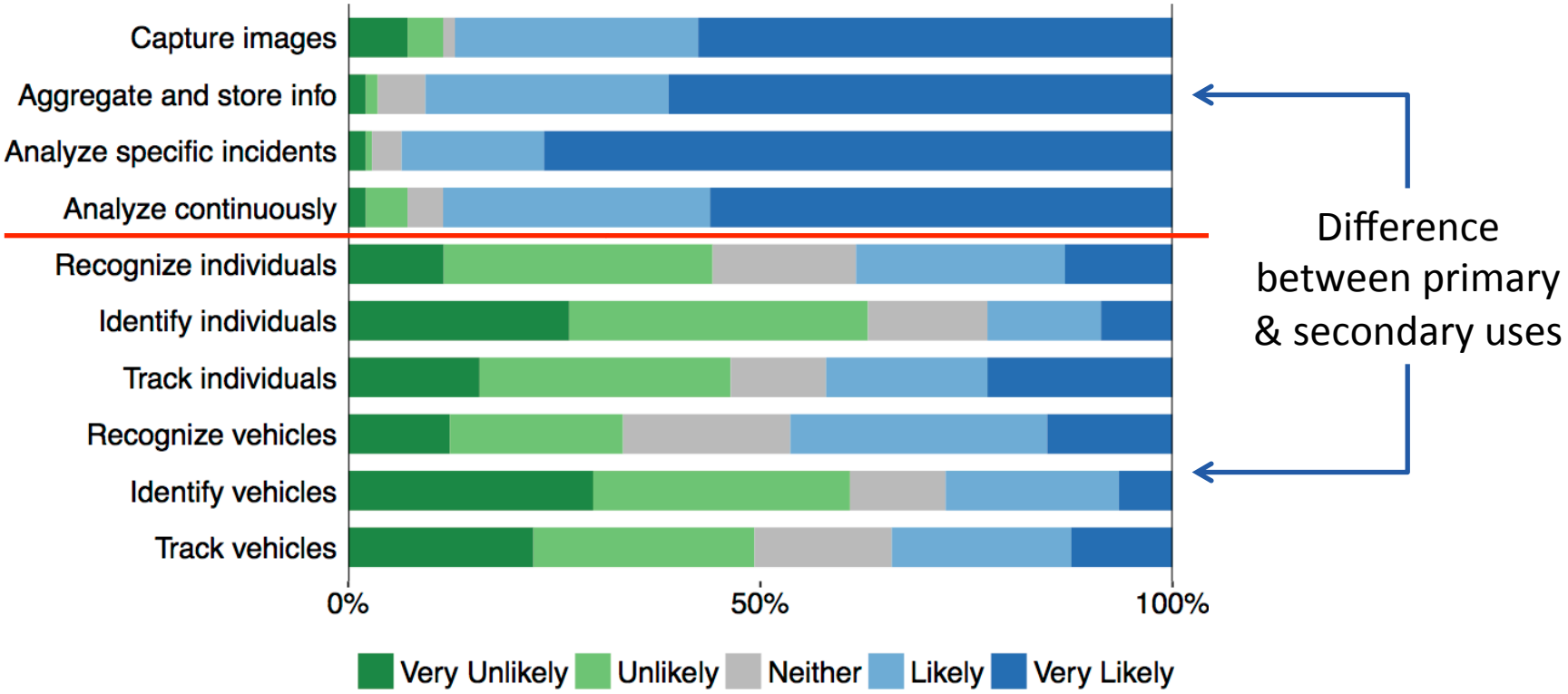
Likelihood of Technical Capability



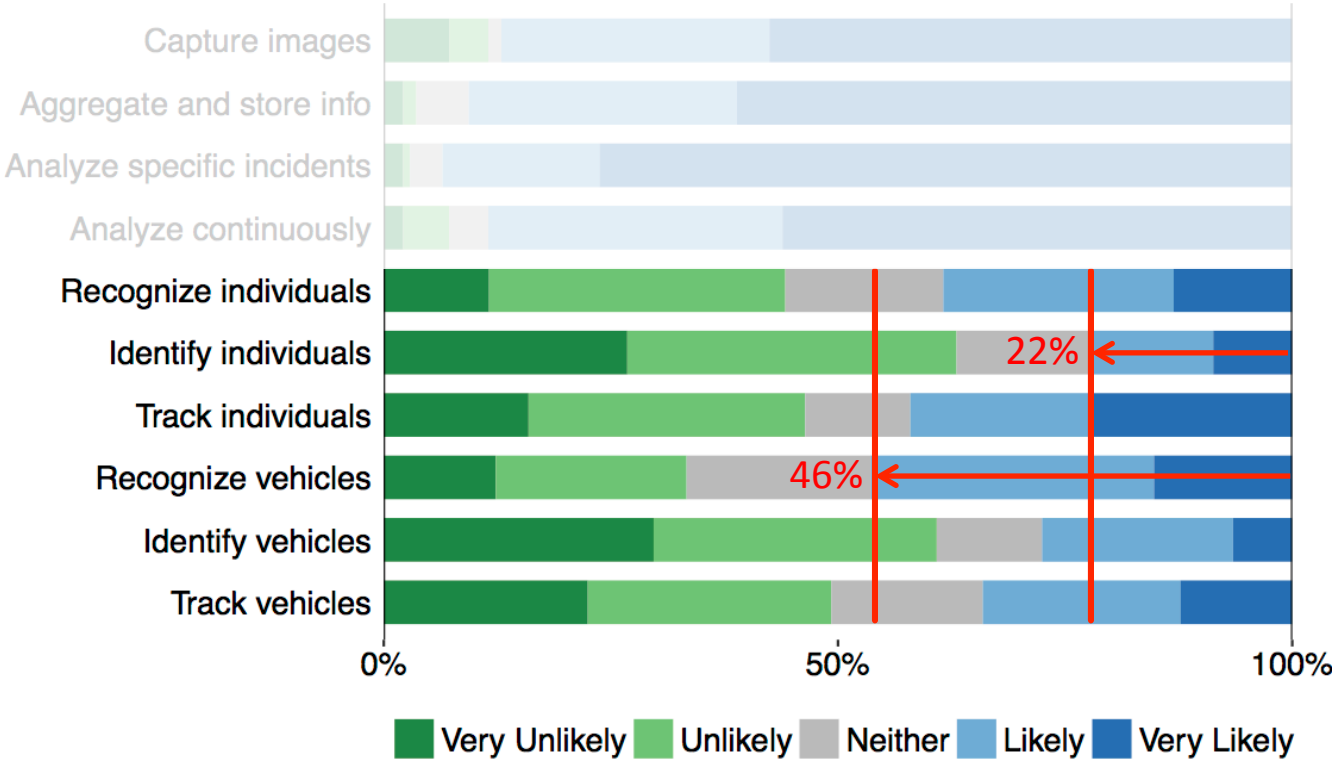
Likelihood of Technical Capability



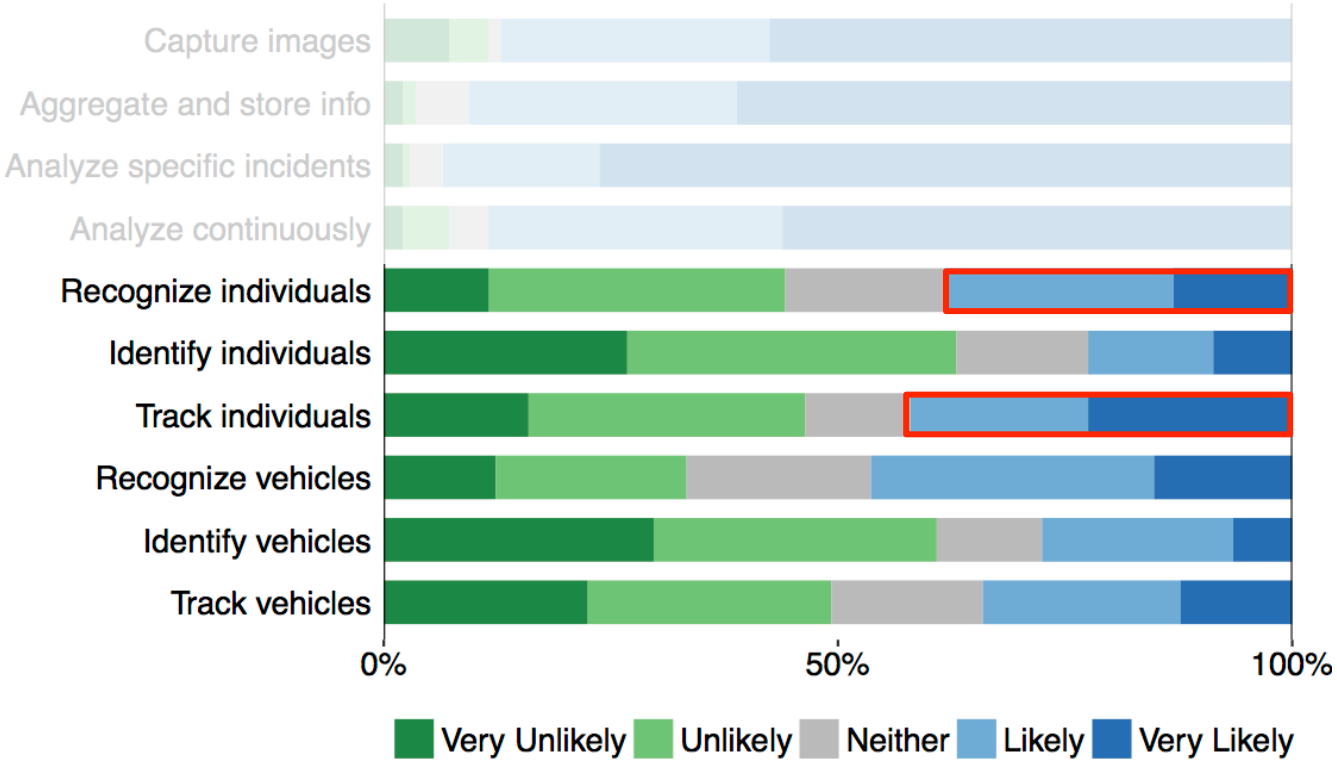
Likelihood of Technical Capability



Likelihood of Technical Capability

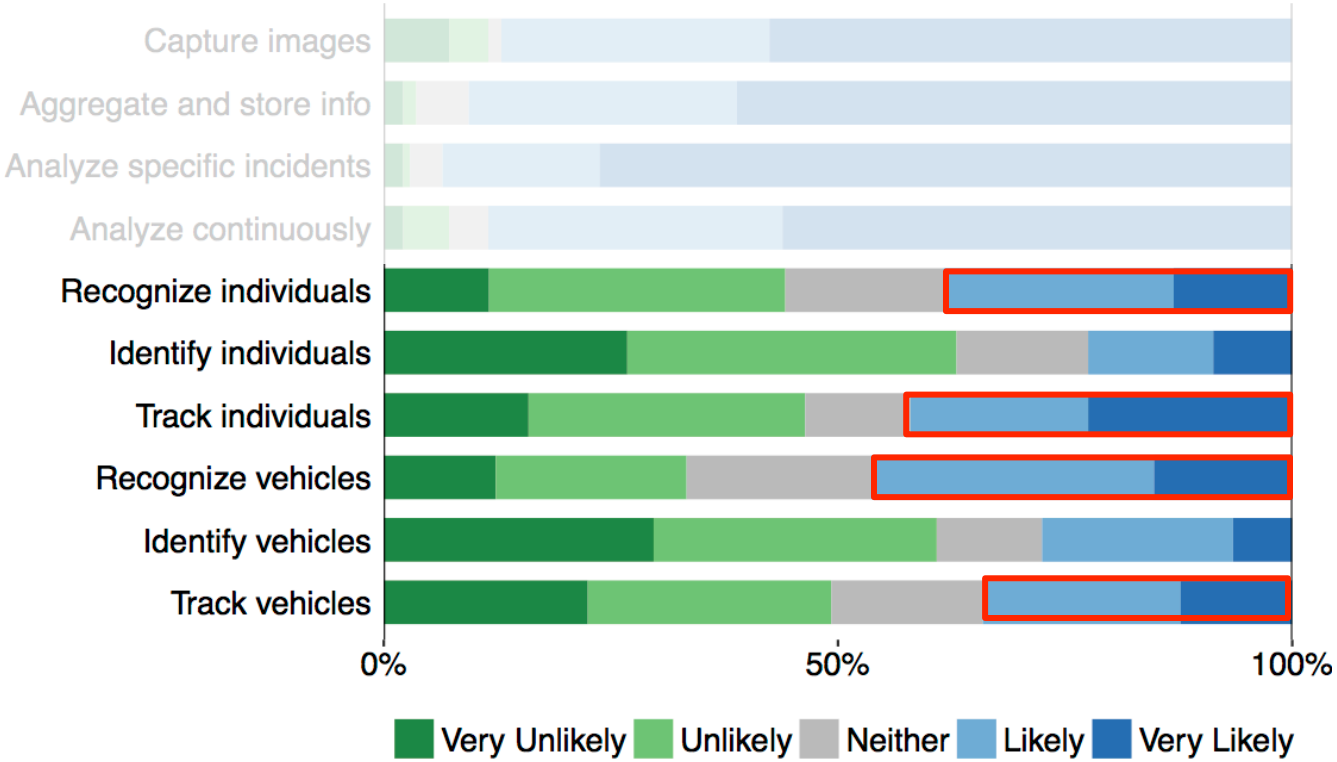


Likelihood of Technical Capability



Participant misconceptions

Likelihood of Technical Capability



Participant misconceptions

Question:

How comfortable are people with these potential capabilities?

Comfort with Capability Scenarios

Primary Uses	Image Capture	Aggregation & Storage	Specific Incident Analysis	Continuous Analysis
Secondary Uses – Perceiving People	Recognition	Identification	Tracking	
Secondary Uses – Perceiving Vehicles	Recognition	Identification	Tracking	

Comfort with Capability Scenarios

Capture images

Aggregate and store info

Analyze specific incidents

Analyze continuously

Recognize individuals

Identify individuals

Track individuals

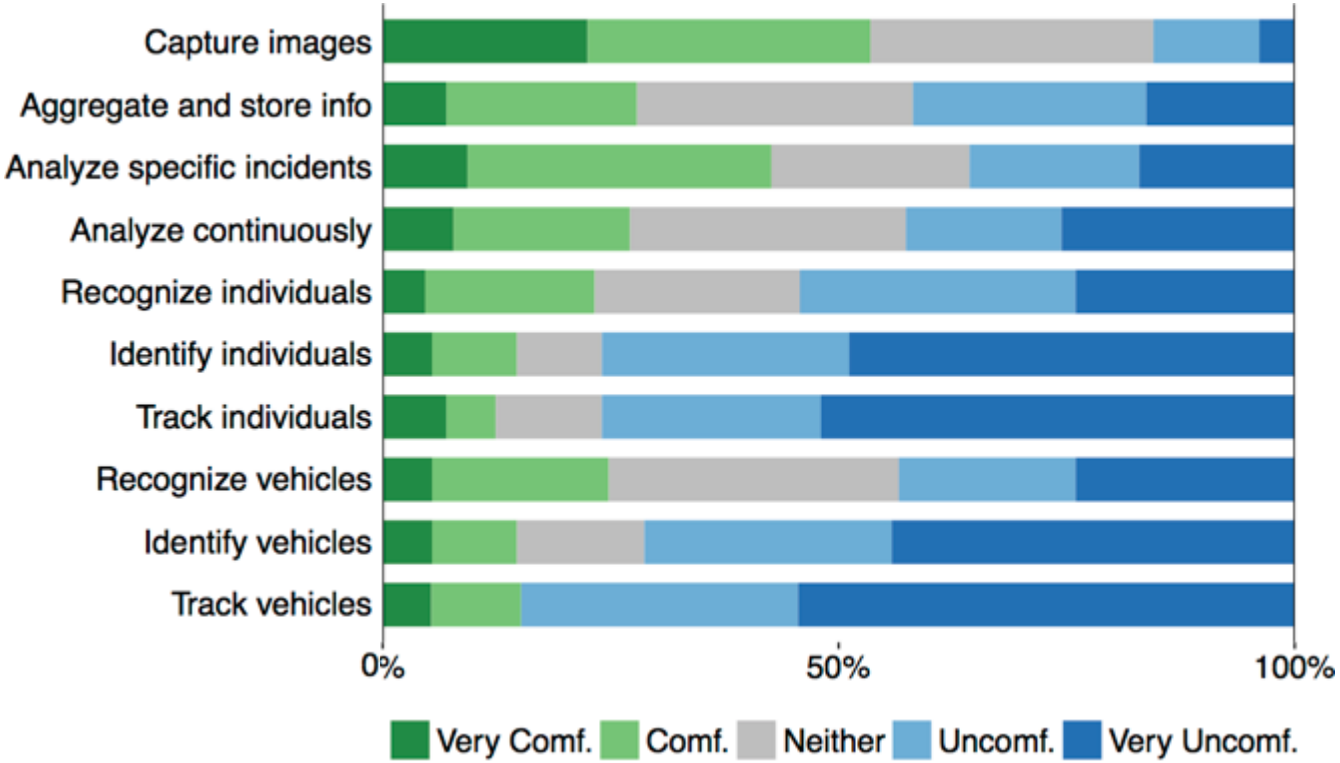
Recognize vehicles

Identify vehicles

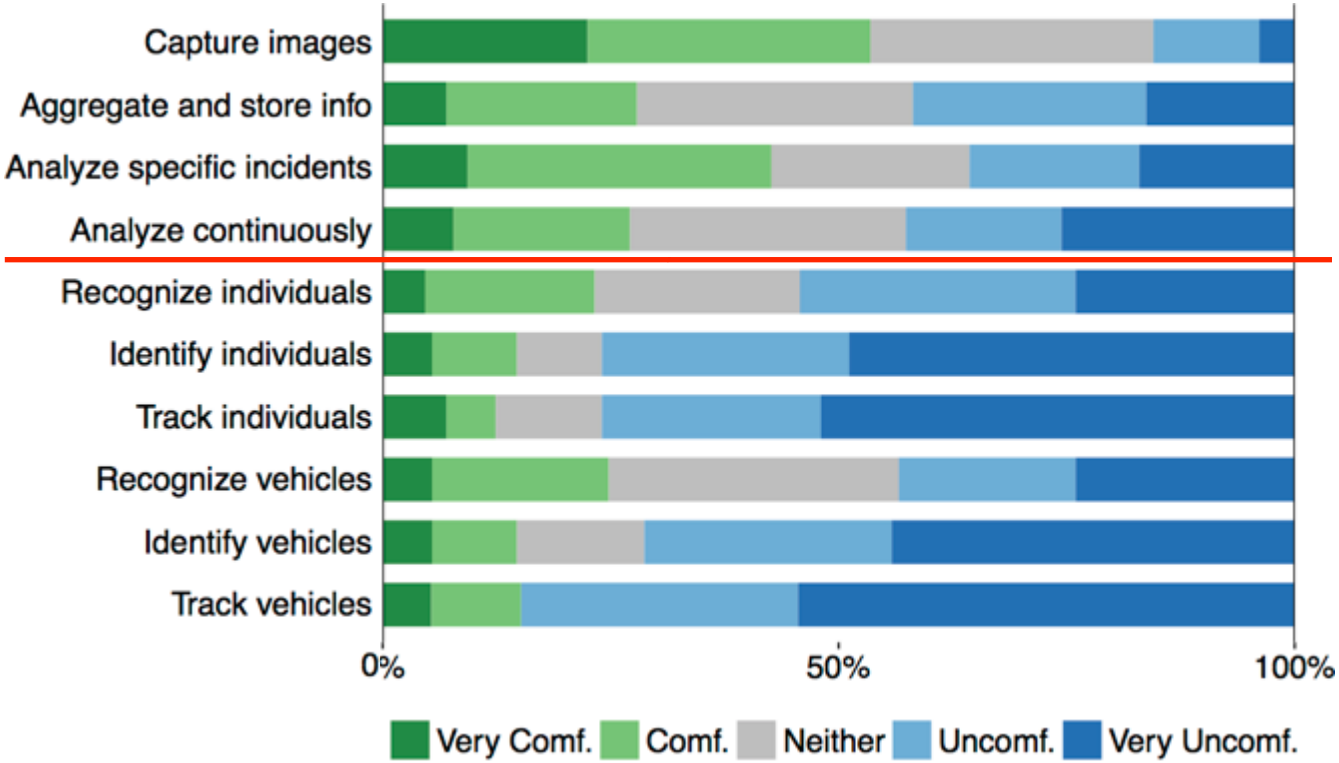
Track vehicles

How comfortable are you with the scenario?

Comfort with Capability Scenarios

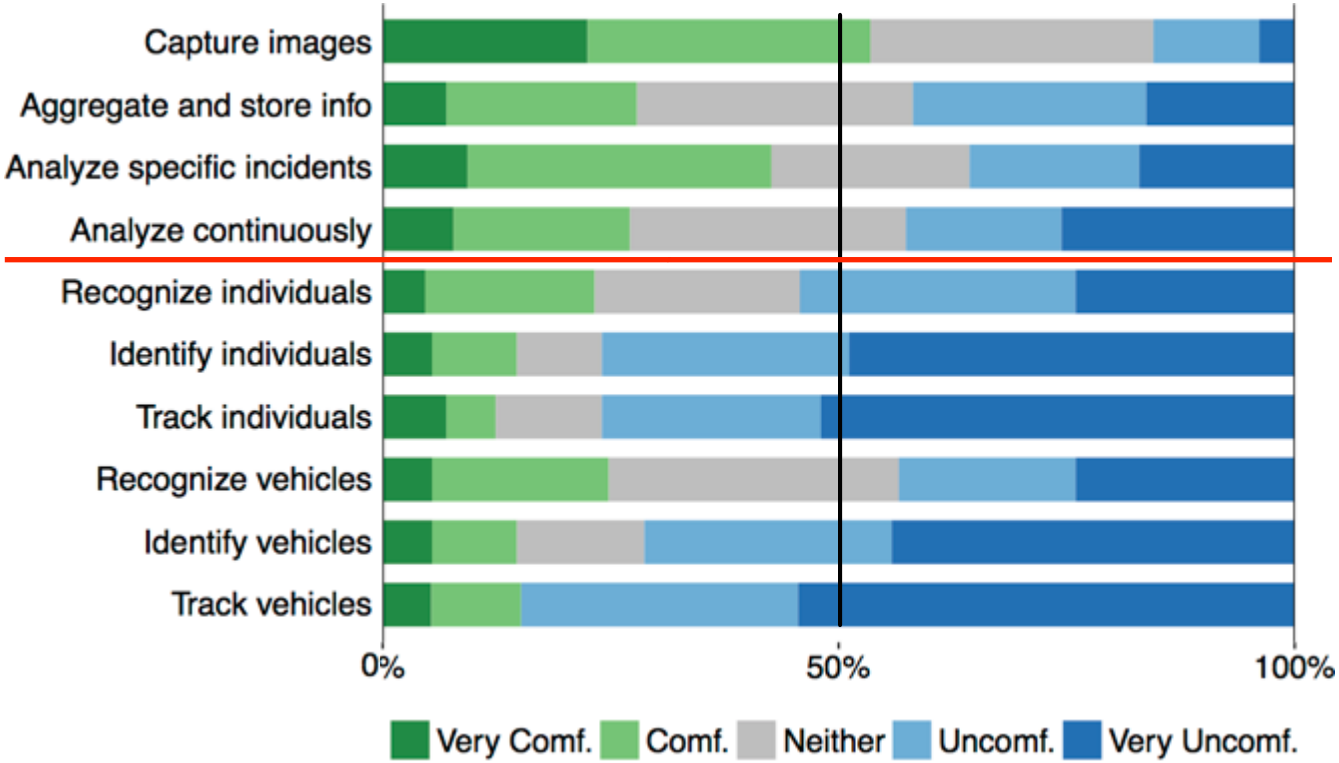


Comfort with Capability Scenarios



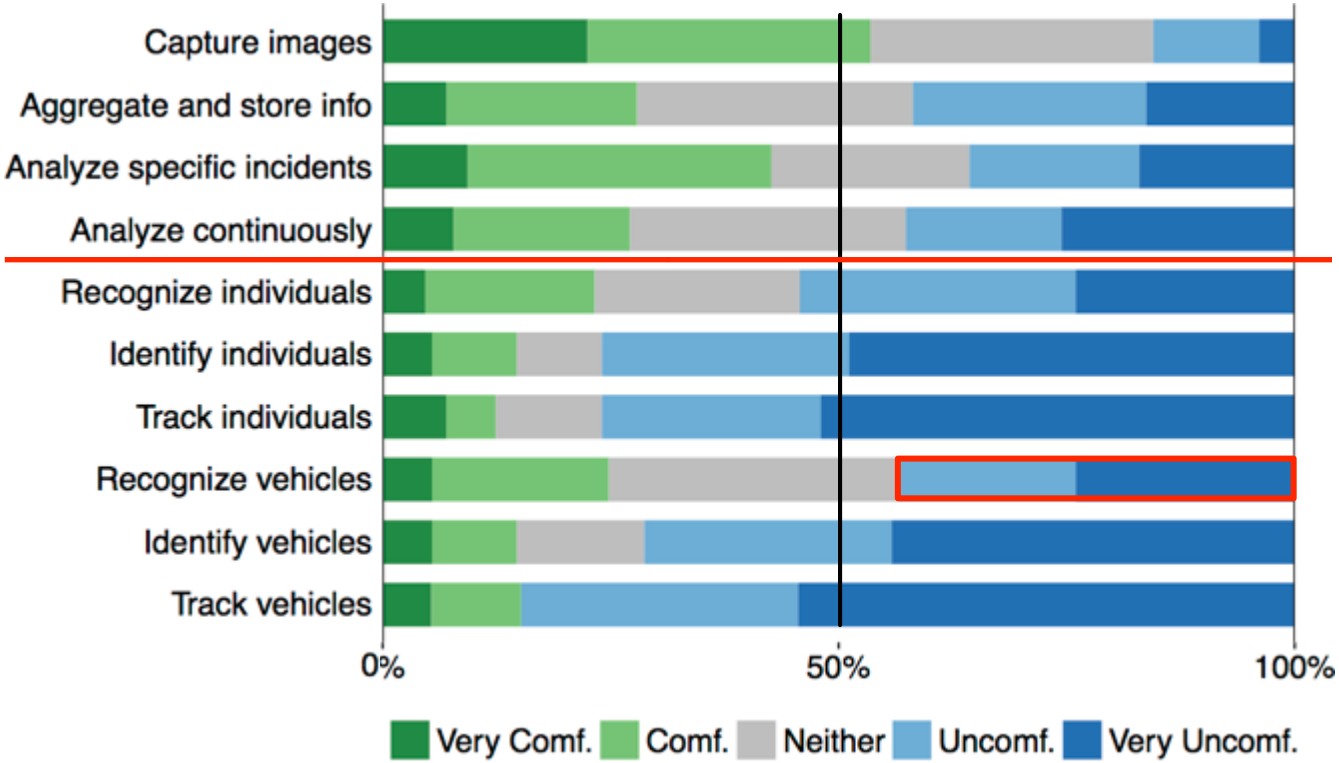
Differentiation is less clear than for likelihood questions

Comfort with Capability Scenarios



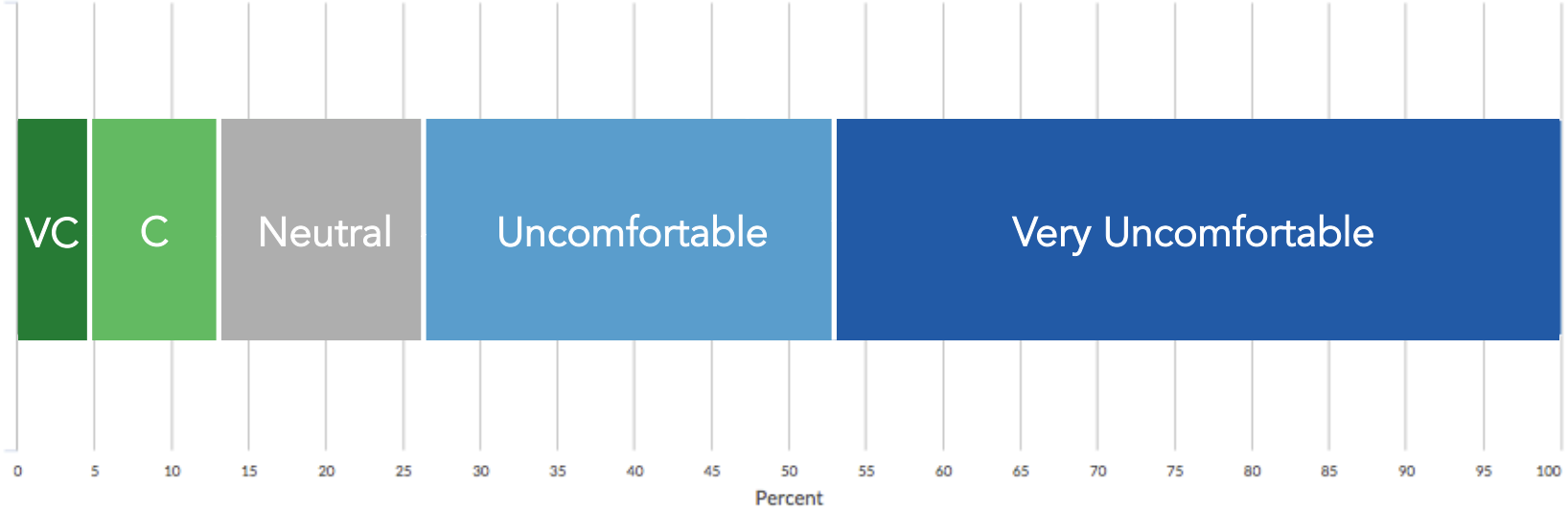
Differentiation is less clear than for likelihood questions

Comfort with Capability Scenarios



Exception: recognition of vehicles

Why are people (un)comfortable?

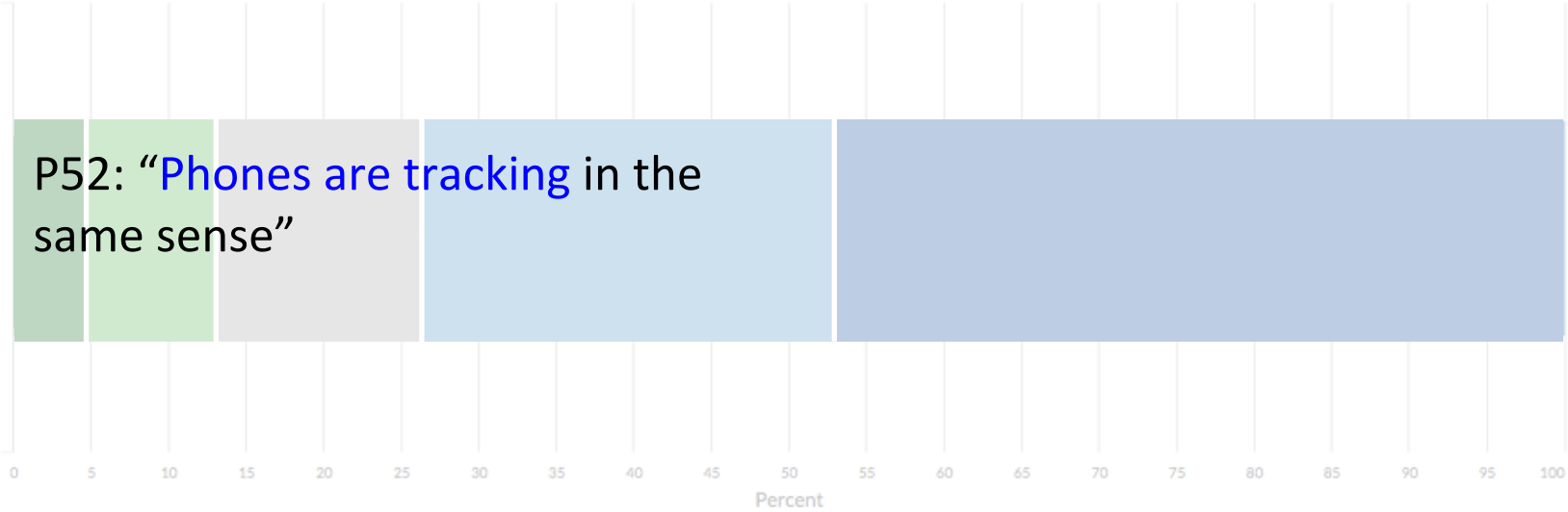


Q25. I would feel _____ if my car was tracked each time it encountered a self-driving car.

Why are people comfortable?

Reasonable benefit

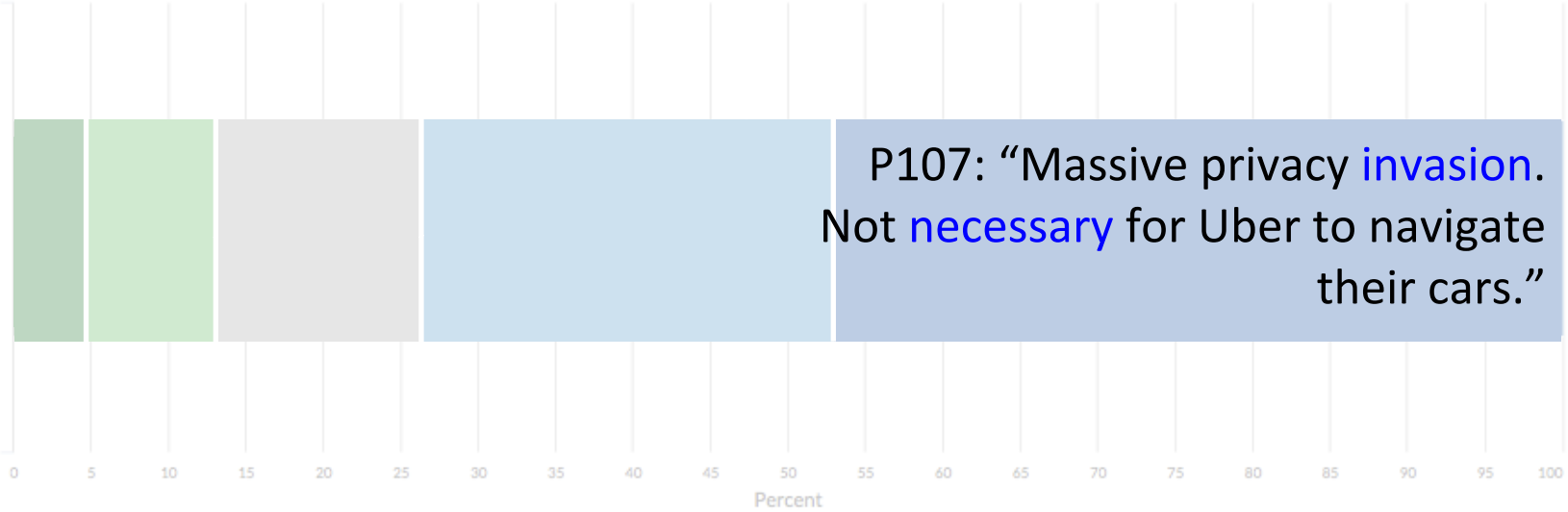
Why are people comfortable?



Reasonable benefit

Ubiquity

Why are people uncomfortable?



Ubiquity

Reasonable benefit

Necessary for AVs

Why are people uncomfortable?

Ubiquity

Reasonable benefit

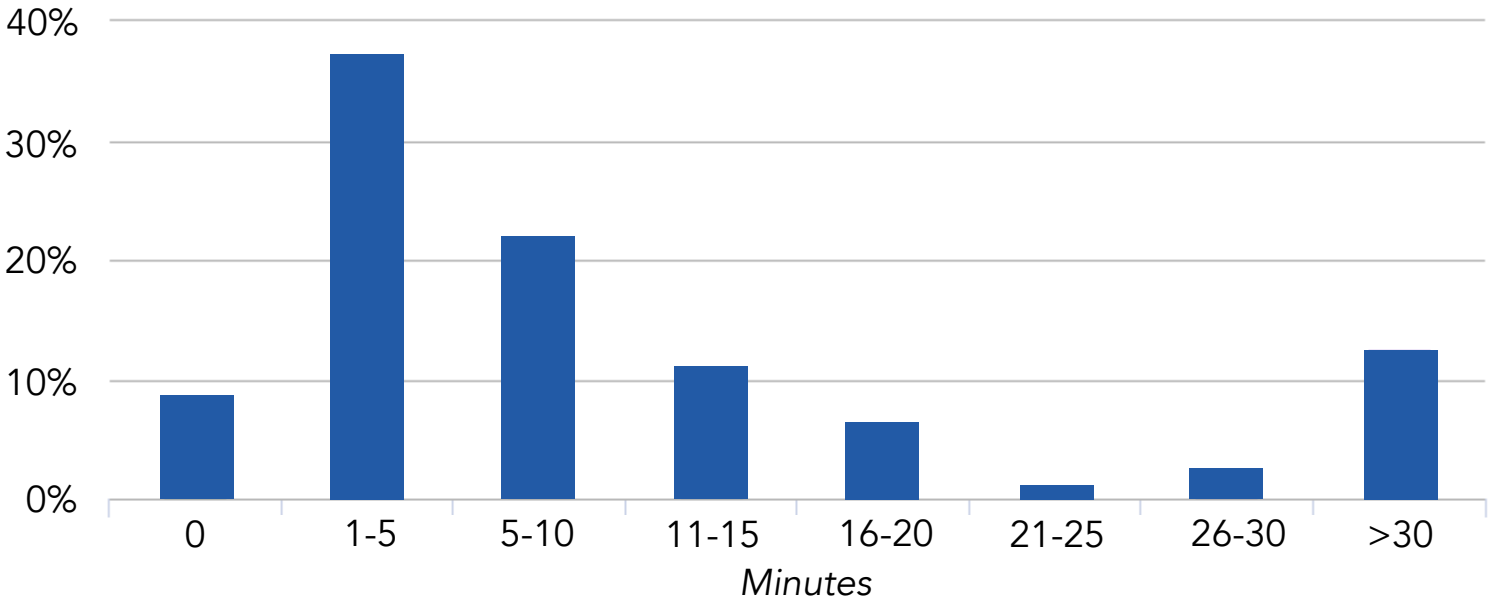
Necessity for AVs

Consent

Question:

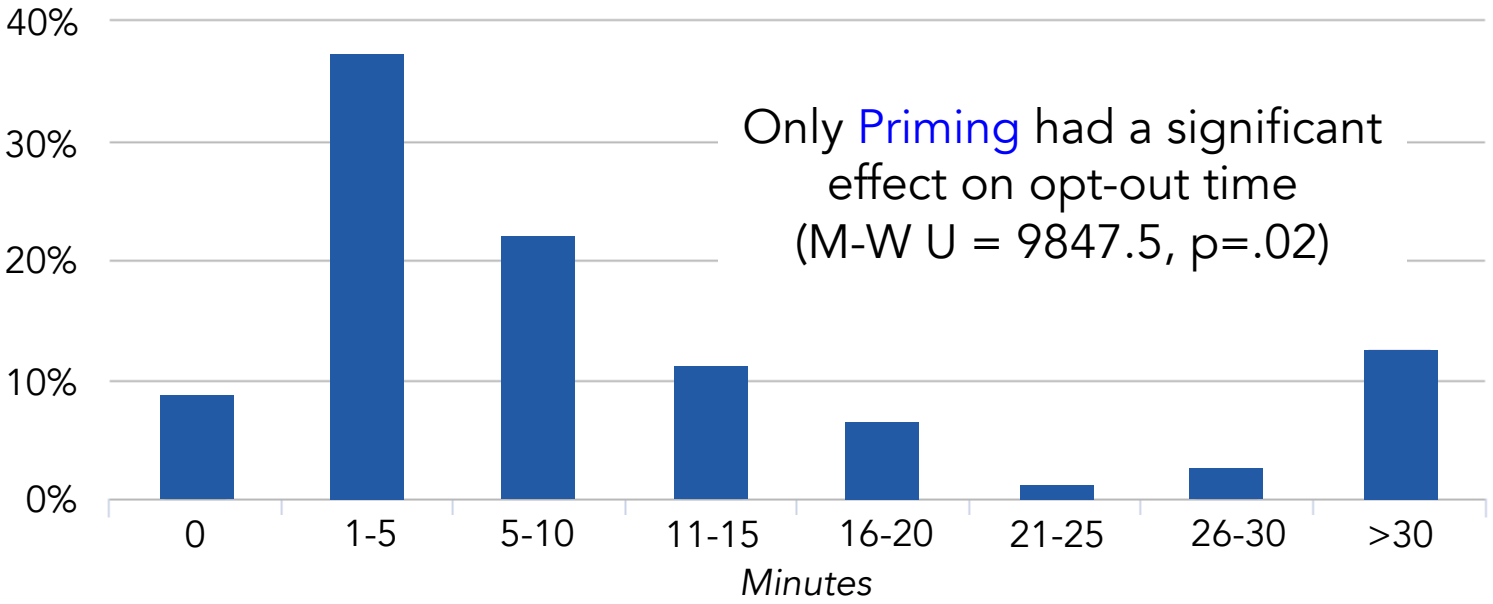
How much effort would people expend to opt out?

Effort to Opt Out



Q36. How many minutes would you spend in the system to successfully opt out?

Effort to Opt Out



Q36. How many minutes would you spend in the system to successfully opt out?

In the Paper:

- More correlation tests
- Comparison of privacy and safety comfort
- Uber-related exposure and bias

Takeaways

Takeaways

1. People differentiate between primary and secondary data uses

Takeaways

1. People differentiate between primary and secondary uses
2. Justifications focused on necessity, consent, and ubiquity

Takeaways 1-2: Policy Application

Takeaways 1-2: Policy Application

Primary uses are reasonable, while secondary uses are not

Takeaways 1-2: Policy Application

Primary uses are reasonable, while secondary uses are not

Possible Exception: Recognition of vehicles

Takeaways

3. Misconceptions about new information

Takeaways

3. Misconceptions about new information
4. Priming had the only significant effect on effort to opt-out

Takeaways 3-4: Policy Application

People will likely react strongly to conversations about autonomous vehicle privacy

Takeaways 3-4: Policy Application

People will likely react strongly to conversations about autonomous vehicle privacy

And, it may be difficult to relay accurate information

The Big Picture

- Companies should self-regulate

The Big Picture

- Companies should self-regulate
  - .. to get ahead of the narrative
  - .. to fulfill reasonable expectations

The Big Picture

- Companies should self-regulate

- Policy should restrict secondary uses of AV-collected information

The Big Picture

- Companies should self-regulate

- Policy should restrict secondary uses of AV-collected information

Self-driving Cars & Data Collection

Privacy Perceptions of Networked Autonomous Vehicles

Cara Bloom, Joshua Tan, Javed Ramjohn, Lujo Bauer

Carnegie Mellon University

10. A self-driving car recognizes a person that has been encountered before by a different self-driving car in the fleet

◯ Very Unlikely
◯ Unlikely
◯ Neither Unlikely nor Likely
◯ Likely
◯ Very Likely

11. Individuals are identified by name when they encounter one of the self-driving cars in the fleet

For example: Uber knows that the pedestrian next to one of its self-driving cars is Alice

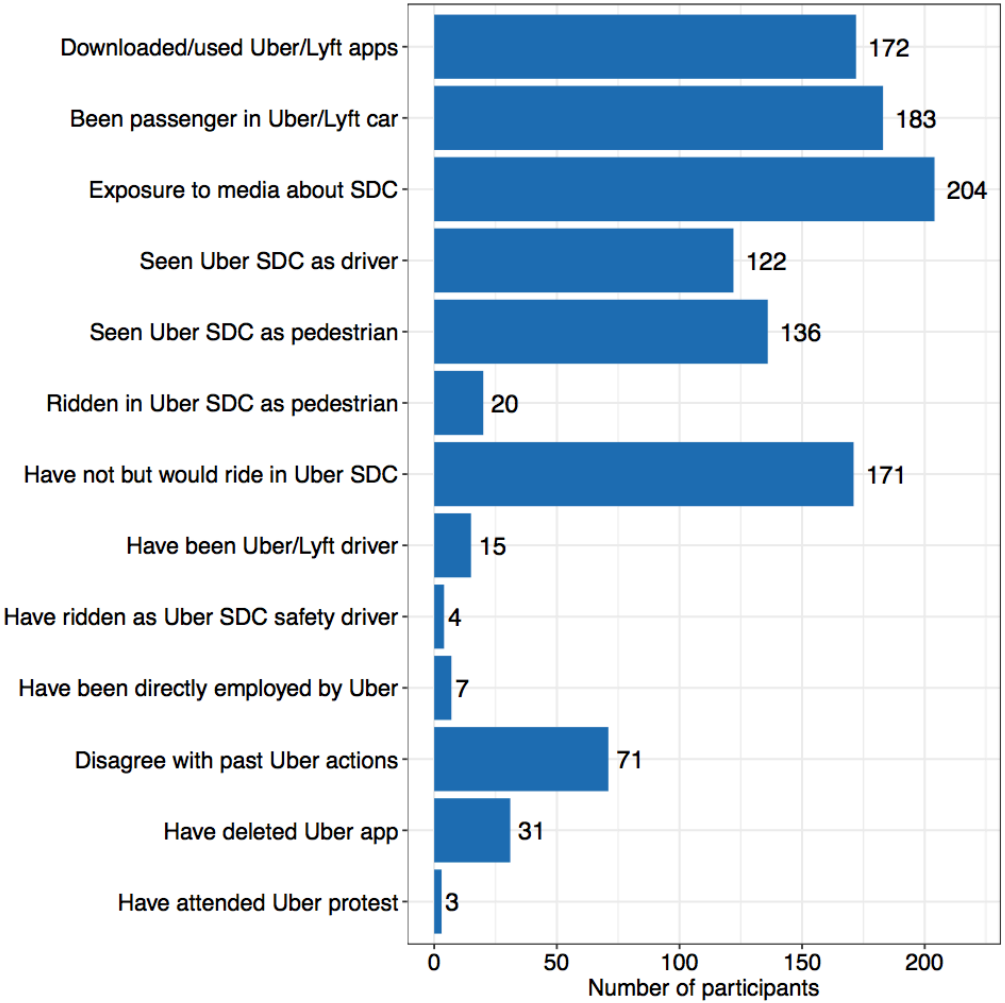
◯ Very Unlikely
◯ Unlikely
◯ Neither Unlikely nor Likely
◯ Likely
◯ Very Likely

12. Individuals are tracked using each time they encounter one of its self-driving cars in the fleet

◯ Very Unlikely
◯ Unlikely
◯ Neither Unlikely nor Likely
◯ Likely
◯ Very Likely

Scenario	Overall	PGH	Non-PGH
Capture images	16% (20)	14% (13)	19% (7)
Aggregate and store info	42% (54)	43% (40)	38% (14)
Analyze specific incidents	36% (46)	36% (33)	35% (13)
Analyze continuously	43% (55)	39% (36)	51% (19)
Recognize individuals	54% (70)	57% (52)	49% (18)
Identify individuals	76% (98)	75% (69)	78% (29)
Track individuals	76% (98)	78% (72)	70% (26)
Recognize vehicles	43% (56)	46% (42)	38% (14)
Identify vehicles	71% (92)	68% (63)	78% (29)
Track vehicles	85% (95)	84% (67)	88% (28)

Table 2: Discomfort with technological capabilities in different scenarios, overall and by whether participants lived in Pittsburgh. The percentage (count) of participants that were uncomfortable or very uncomfortable with a scenario are shown.

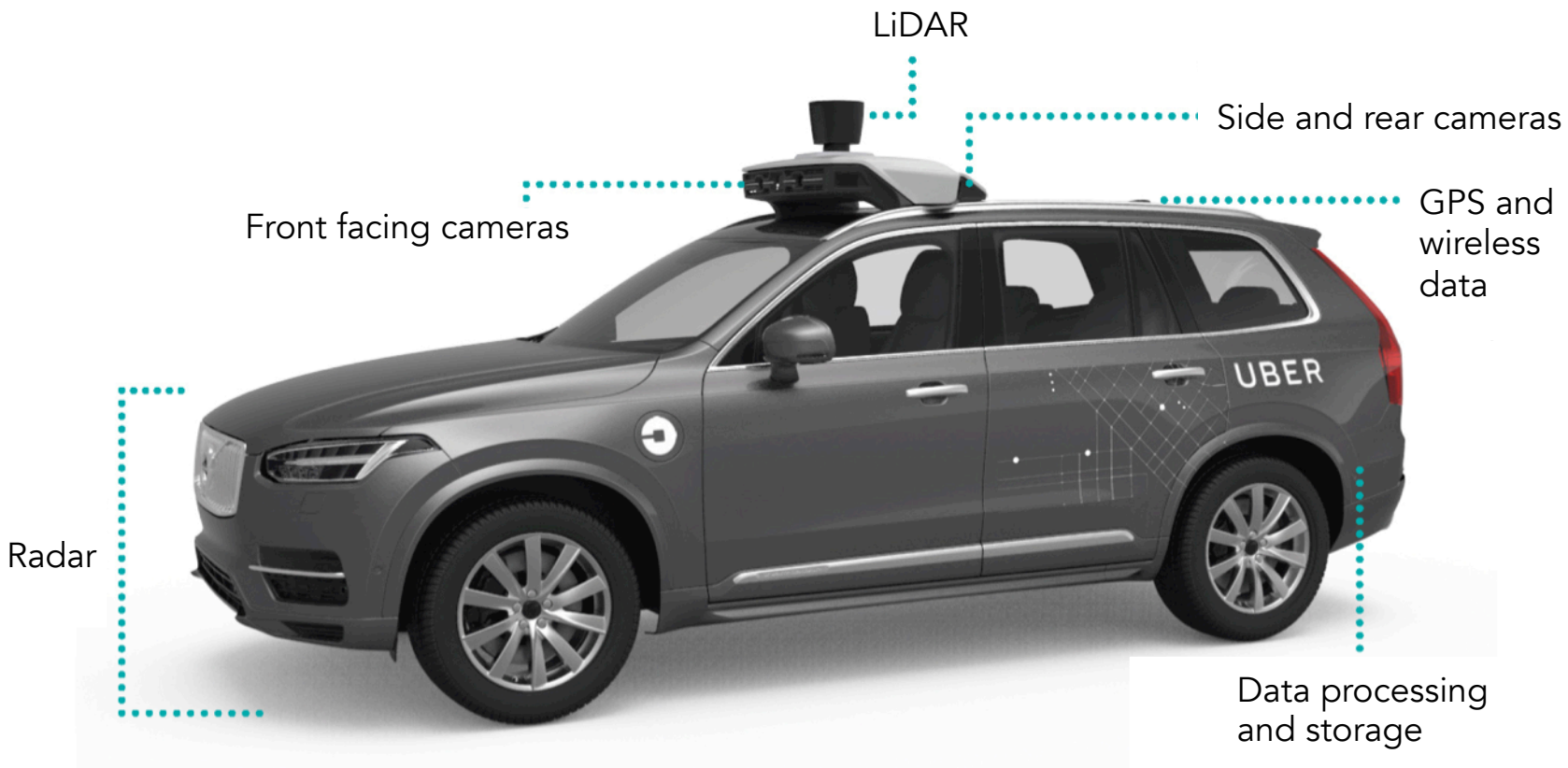

Downloaded/used Uber/Lyft apps
172
Been passenger in Uber/Lyft car
183
Exposure to media about SDC
204
Seen Uber SDC as driver
122
Seen Uber SDC as pedestrian
136
Ridden in Uber SDC as pedestrian
20
Have not but would ride in Uber SDC
171
Have been Uber/Lyft driver
15
Have ridden as Uber SDC safety driver
4
Have been directly employed by Uber
7
Disagree with past Uber actions
71
Have deleted Uber app
31
Have attended Uber protest
3
0
50
100
150
200
Number of participants

Exposure to Uber & AV technology

- 78% Pgh and 42% non-Pgh were exposed to media
- 64% Pgh and 3% non-Pgh had seen one as a pedestrian

Bias against Uber

- 17% would have answered differently if Uber hadn’t been the example
- 18% would trust a different AV company over Uber to have their best interests in mind


LiDAR
Side and rear cameras
Front facing cameras
GPS and wireless data
Radar
Data processing and storage
UBER


UBER
Self-driving
Pittsburgh, PA

Progression of General Scenarios