



EVAadopt: De-biasing Electric Vehicle Adoption with Personalized Nudging

Ursa Bernardic, Davide Cerruti, Massimo Filippini, Jonas Savelsberg, Giuseppe Ugazio






Overview

- Introduction
- Methodological approach
- Results
- Conclusions

Insight from prior research & motivation

- While the global adoption of battery electric vehicles (EV) is slowly increasing, the share of the total vehicle stock remains low (Switzerland in 2023 -> 3,26%, UK in 2023 -> 2.52%) (FSO, 2024; ZapMap, 2024)
- Many consumers still **lack knowledge and are skeptical** about EV adoption (Needell et al., 2022; Li et al., 2017; Singh, Singh & Vaibhav, 2020)

Research question

- What is the extent of psychological barriers for EV adoption for current car owners?
 -  **Range anxiety**—the worry that a given battery range will be insufficient to reach a destination
 -  **Charging anxiety**—fear that EV driver will have to charge too many times per week
 -  **Total Cost of Ownership** —the overall cost associated with owning and operating an EV
- Can providing **personalized information** on range, charging and TCO compatibility **increase** the adoption of an electric car?

Methodological approach

Experimental Design

Electric Car - Share of Trips

In the following, we would like for you to imagine that you owned an electric car in 2022 and that your driving behaviour remained the same. For each of the battery ranges presented below, please estimate the share of car trips that you could have covered without recharging. Car trips means all one-way car trips (i.e. inbound and return trip counted separately), completed with you as the driver.

Please report the percentage of total car trips that you think you could have covered with the respective electric cars and battery ranges in 2022 (yearly). For example, if you could have covered all of your one-way trips in the year 2022 with a specific battery range, move the slider to 100. If you could only have covered 50% of all of your one-way trips in the year 2022 with a specific range move the slider to 50. Please adjust all sliders according to your responses and be aware that moving the first slider is necessary to proceed.

Electric car with a battery range of 420 miles:

50% of all trips could be covered with a battery range of 420 miles

Electric car with a battery range of 370 miles:

50% of all trips could be covered with a battery range of 370 miles

Electric car with a battery range of 320 miles:

50% of all trips could be covered with a battery range of 320 miles

Electric car with a battery range of 270 miles:

50% of all trips could be covered with a battery range of 270 miles

Electric car with a battery range of 220 miles:

50% of all trips could be covered with a battery range of 220 miles

Electric car with a battery range of 170 miles:

50% of all trips could be covered with a battery range of 170 miles

Driving Diary - Work Week and Weekend

Please think about the length of car trips that you completed on a daily basis in an average work week and weekend in 2022 and fill in the following form.

Please note: Count outward and return trips separately - for example, if you drive 15 miles to your workplace on five workdays, please indicate the number 15 in the answer fields next to Monday till Friday for trip 1 and trip 2. Please note that a value is required for Trip 1 on Monday to continue. If you never travel on Mondays please input 0 for Trip 1.

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Monday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Tuesday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Wednesday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Thursday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Friday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Sunday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Please assume that you have decided to replace your car.

Please think carefully about what you would do in a real-world situation and respond sincerely.

Which car would you prefer to buy?

Model	VW ID.3 Pure Performance Style	Model	VW Golf 8 1.5 eTSI Style
Drivetrain	Rear wheel drive	Drivetrain	Front wheel drive
Power	150	Power	150
Transmission	Automatic	Transmission	Automatic
Consumption	Electric 14.9 kWh/100km	Consumption	Petrol 5.9 l/100km
Price	£ 34945	Price	£ 31845
Range (WLTP)	217 miles / 349 km	Range (WLTP)	526 miles / 847 km

Electric Car
VW ID.3 Pure Perform

Petrol Car
VW Golf 8 1.5 eTSI style

Socio-economic demographics

Where do you live?

City

Suburbs

Rural area

What is your living situation

Multi family house

Single family house

Apartment

Residential facility

How many people live in your household?

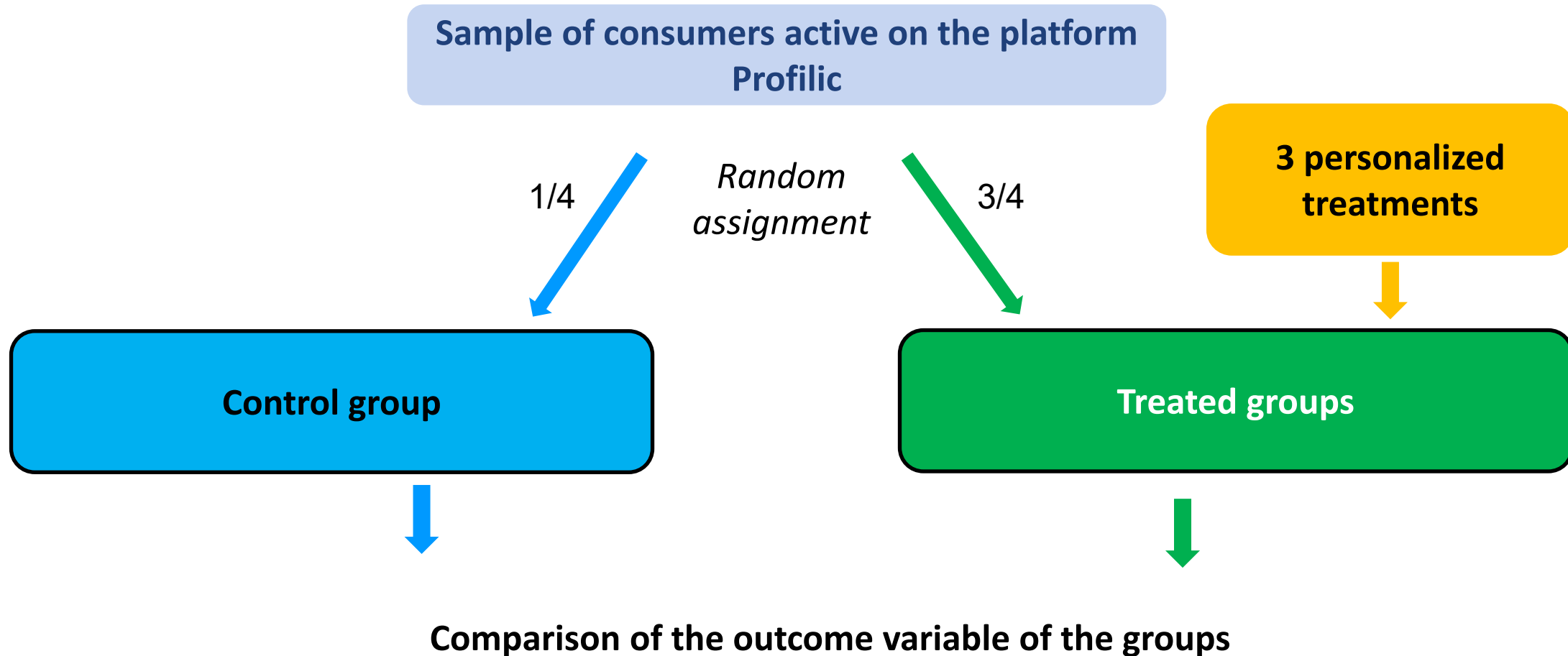
Measure perception biases

Driving and parking diary

Stated choice RCT

Questionnaire

Method: stated choice approach combined with a randomized control trial





Control Treatment


Please assume that you have decided to replace your car.


Please think carefully about what you would do in a real-world situation and respond sincerely.

Which car would you prefer to buy?





Model	VW ID.3 Pure Performance Style
Drivetrain	Rear-wheel drive
Power	150
Transmission	Automatic
Consumption 	Electric 14.9 kWh/100km
Price	£ 34'945
Range (WLTP)	217 miles / 349 km

Model	VW Golf 8 1.5 eTSI Style
Drivetrain	Front-wheel drive
Power	150
Transmission	Automatic
Consumption 	Petrol 5.9 l/100km
Price	£ 31'845
Range (WLTP)	526 miles / 847 km

Electric Car
VW ID.3 Pure Perform

Petrol Car
VW Golf 1.5 eTSI Style




Range Compatibility Treatment


We provide information on the number of times per year that the person using an electric car should **stop to recharge** the battery during a trip

Please assume that you have decided to replace your car.

Please think carefully about what you would do in a real-world situation and respond sincerely.

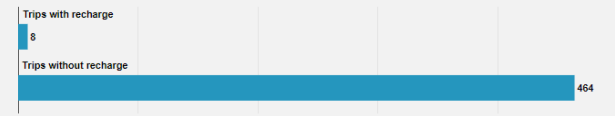
Which car would you prefer to buy?





Model	VW ID.3 Pure Performance Style
Drivetrain	Rear-wheel drive
Power	150
Transmission	Automatic
Consumption [⚡]	Electric 14.9 kWh/100km
Price	£ 34'945
Range (WLTP)	217 miles / 349 km

Based on **your** driving diary, we calculated that out of 472 trips that you do per year, you would only have to interrupt your trip to recharge **8 times per year** because the trip distance exceeds the range of VW ID.3 Pure Performance Style.

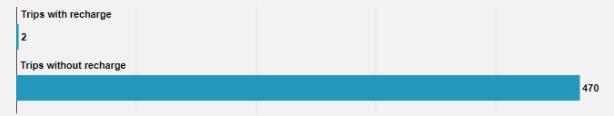


Assuming a minimum battery or fuel tank level of 10 percent before recharging or refueling.

Electric Car
VW ID.3 Pure Perform

Model	VW Golf 8 1.5 eTSI Style
Drivetrain	Front-wheel drive
Power	150
Transmission	Automatic
Consumption [⛽]	Petrol 5.9 l/100km
Price	£ 31'845
Range (WLTP)	526 miles / 847 km

Based on **your** driving diary, we calculated that out of 472 trips that you do per year, you would only have to interrupt your trip to refuel **2 times per year** because the trip distance exceeds the range of VW Golf 8 1.5 eTSI Style.



Assuming a minimum battery or fuel tank level of 10 percent before recharging or refueling.

Petrol Car
VW Golf 1.5 eTSI Style




Charging Compatibility Treatment


We provide information on the number of times the electric car **should be charged per week & possibility to charge at home/work/groceries**

Please assume that you have decided to replace your car.

Please think carefully about what you would do in a real-world situation and respond sincerely.

Which car would you prefer to buy?





Model	VW ID.3 Pure Performance Style
Drivetrain	Rear-wheel drive
Power	150
Transmission	Automatic
Consumption [⚡]	Electric 14.9 kWh/100km
Price	£ 34'945
Range (WLTP)	217 miles / 349 km
<p>Based on your driving diary, we calculated that you would only have to recharge VW ID.3 Pure Performance Style 1.2 times per week (4.6 times per month).</p> <p>Based on your parking diary, we calculated that your car is parked at home long enough to fill the battery 8 times in one week using a normal household socket. While parked at work, you could fill the battery 12 times per week, and 1 time per week per week while doing groceries.</p> <p><small>Based on an average charging speed of 2.3 kWh per hour at home, 11 kWh per hour at work, 22 kWh per hour at other public charging stations during parking hours according to your weekly parking diary. We assume a minimum battery or fuel level of 20 percent before recharging or refueling.</small></p>	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Electric Car VW ID.3 Pure Perform</div>	
Model	VW Golf 8 1.5 eTSI Style
Drivetrain	Front-wheel drive
Power	150
Transmission	Automatic
Consumption [⛽]	Petrol 5.9 l/100km
Price	£ 31'845
Range (WLTP)	526 miles / 847 km
<p>Based on your driving diary, we calculated that you would only have to recharge VW Golf 8 1.5 eTSI Style 0.5 times per week (1.9 times per month). Each time your vehicle needs refueling, you will have to visit the gas station.</p> <p><small>Based on an average charging speed of 2.3 kWh per hour at home, 11 kWh per hour at work, 22 kWh per hour at other public charging stations during parking hours according to your weekly parking diary. We assume a minimum battery or fuel level of 20 percent before recharging or refueling.</small></p>	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Petrol Car VW Golf 1.5 eTSI Style</div>	



Total Cost of Ownership Treatment

We provide information on **the total cost** of using a combustion engine and an electric car

Please assume that you have decided to replace your car.
Please think carefully about what you would do in a real-world situation and respond sincerely.
Which car would you prefer to buy?

Model	VW ID.3 Pure Performance Style
Drivetrain	Rear-wheel drive
Power	150
Transmission	Automatic
Consumption ⚡	Electric 14.9 kWh/100km
Price	£ 34'945
Range (WLTP)	217 miles / 349 km

Based on your driving diary and average fuel and electricity prices in the UK, we calculated that VW ID.3 Pure Performance Style would cost you **£ 21154 over 4 years**.

Electric Car
VW ID.3 Pure Perform

Model	VW Golf 8 1.5 eTSI Style
Drivetrain	Front-wheel drive
Power	150
Transmission	Automatic
Consumption 🚗	Petrol 5.9 l/100km
Price	£ 31'845
Range (WLTP)	526 miles / 847 km

Based on your driving diary and average fuel and electricity prices in the UK, we calculated that VW Golf 8 1.5 eTSI Style would cost you **£ 23939 over 4 years**.

Petrol Car
VW Golf 1.5 eTSI Style

Based on average service, maintenance and repair costs and depreciation per vehicle mile traveled for the UK, electricity prices of 54p per kWh at home, 51p per kWh at public charging stations and 75p per kWh at rapid charging stations for long-distance trips and petrol cost of 147p per liter.

Data and results

Sample

- **3181 car owners from the UK acquired through Prolific**

56.9 % female

Mean age 39 (SD: 11.4)

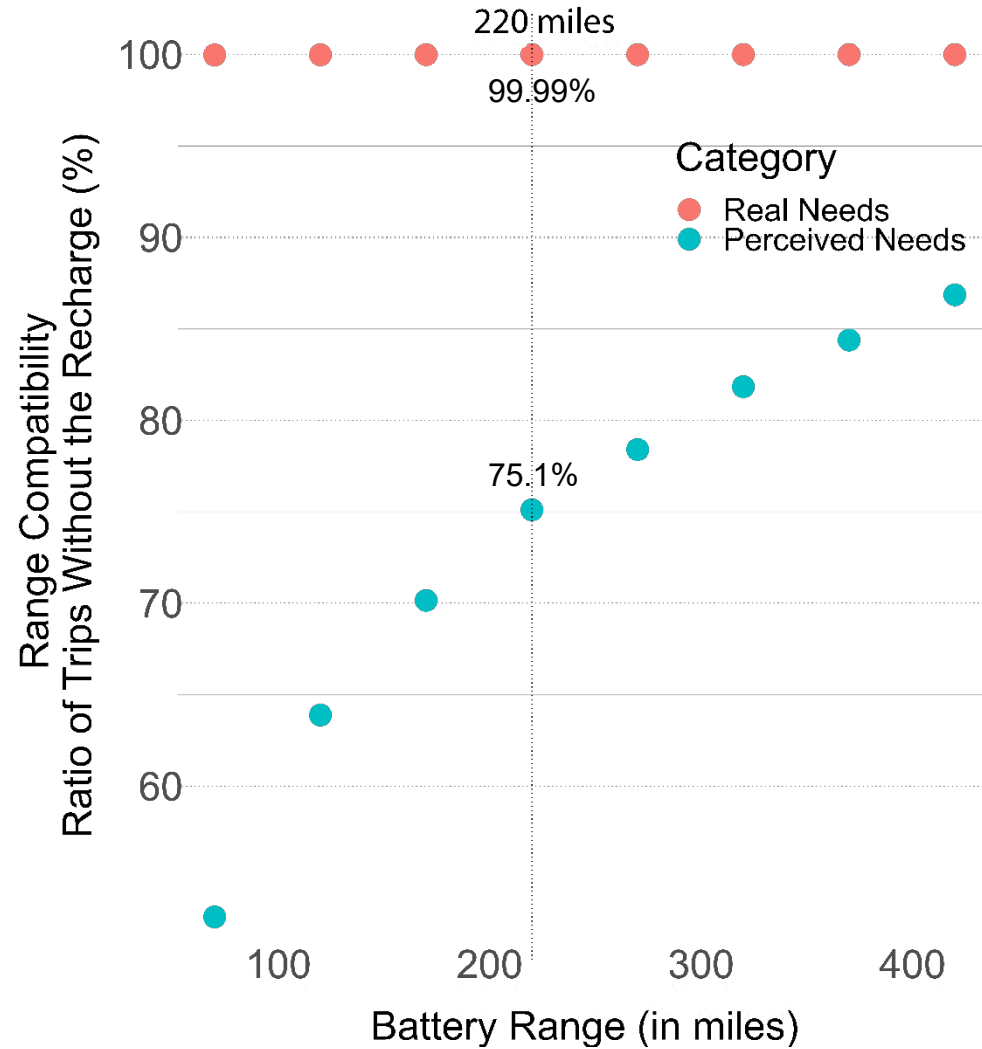
76 % live in single-family house

54 % live in suburbs

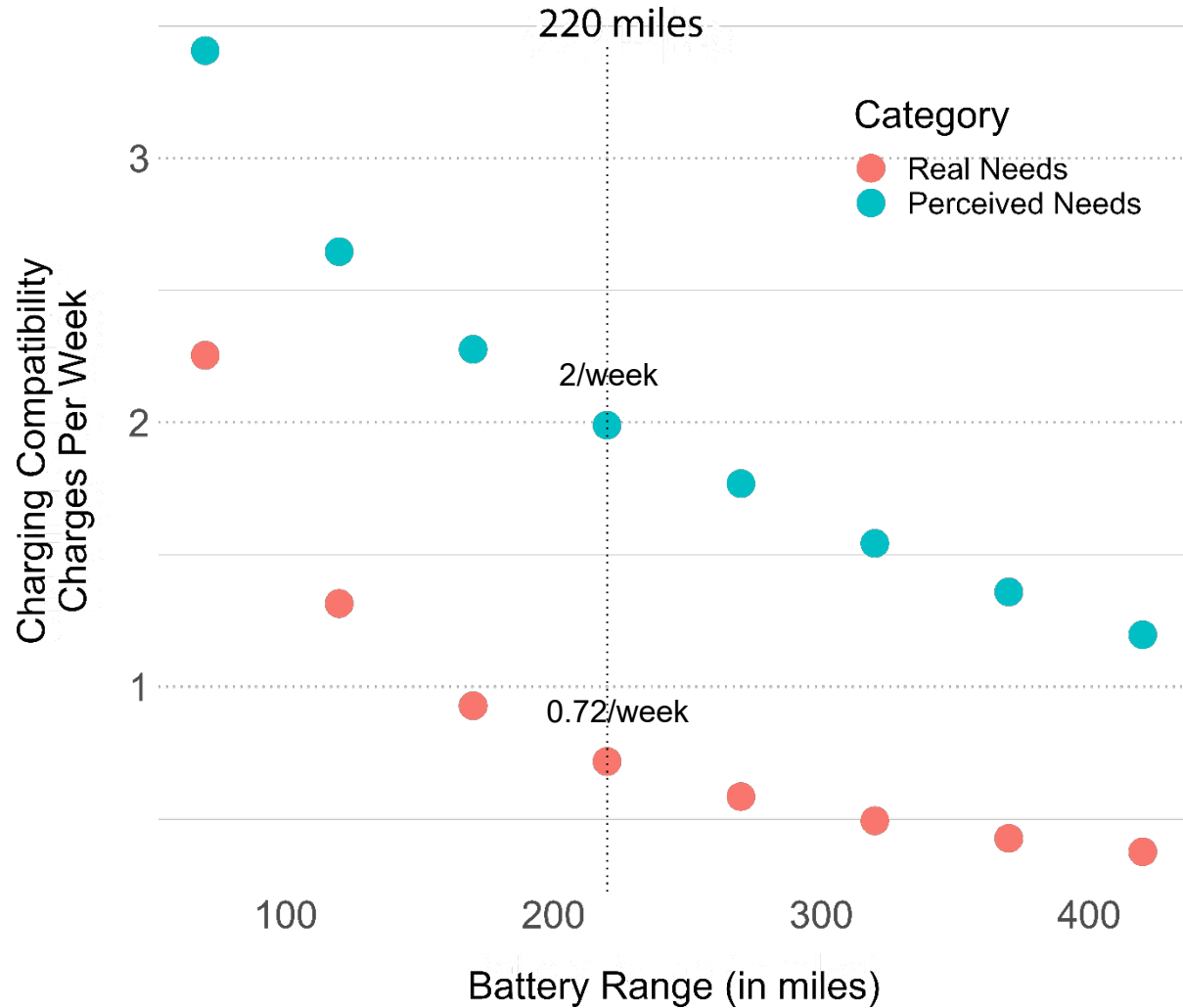
Car ownership

- 66% gasoline
- 25% diesel
- 6% hybrid
- 3% Electric

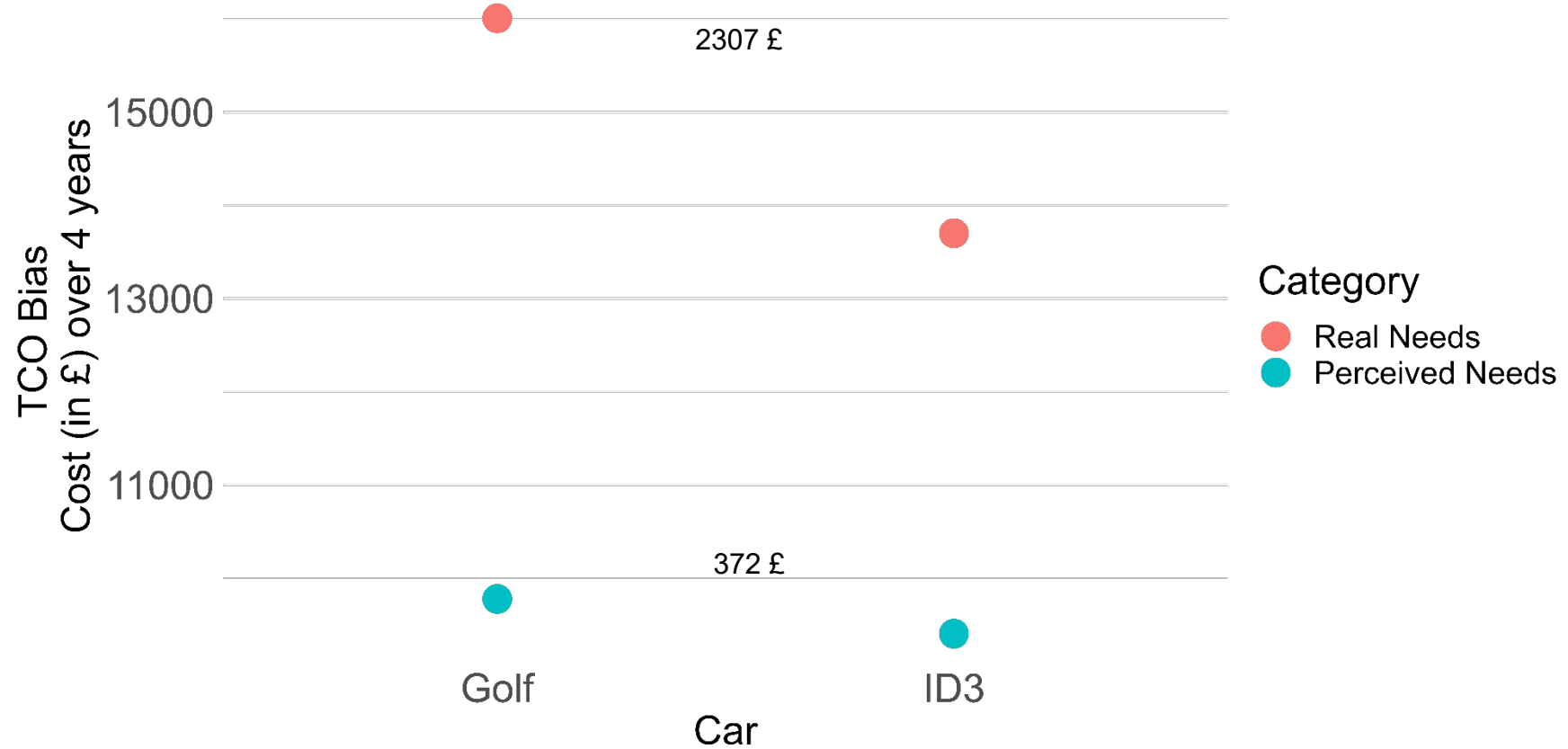
Compatibility bias: Range



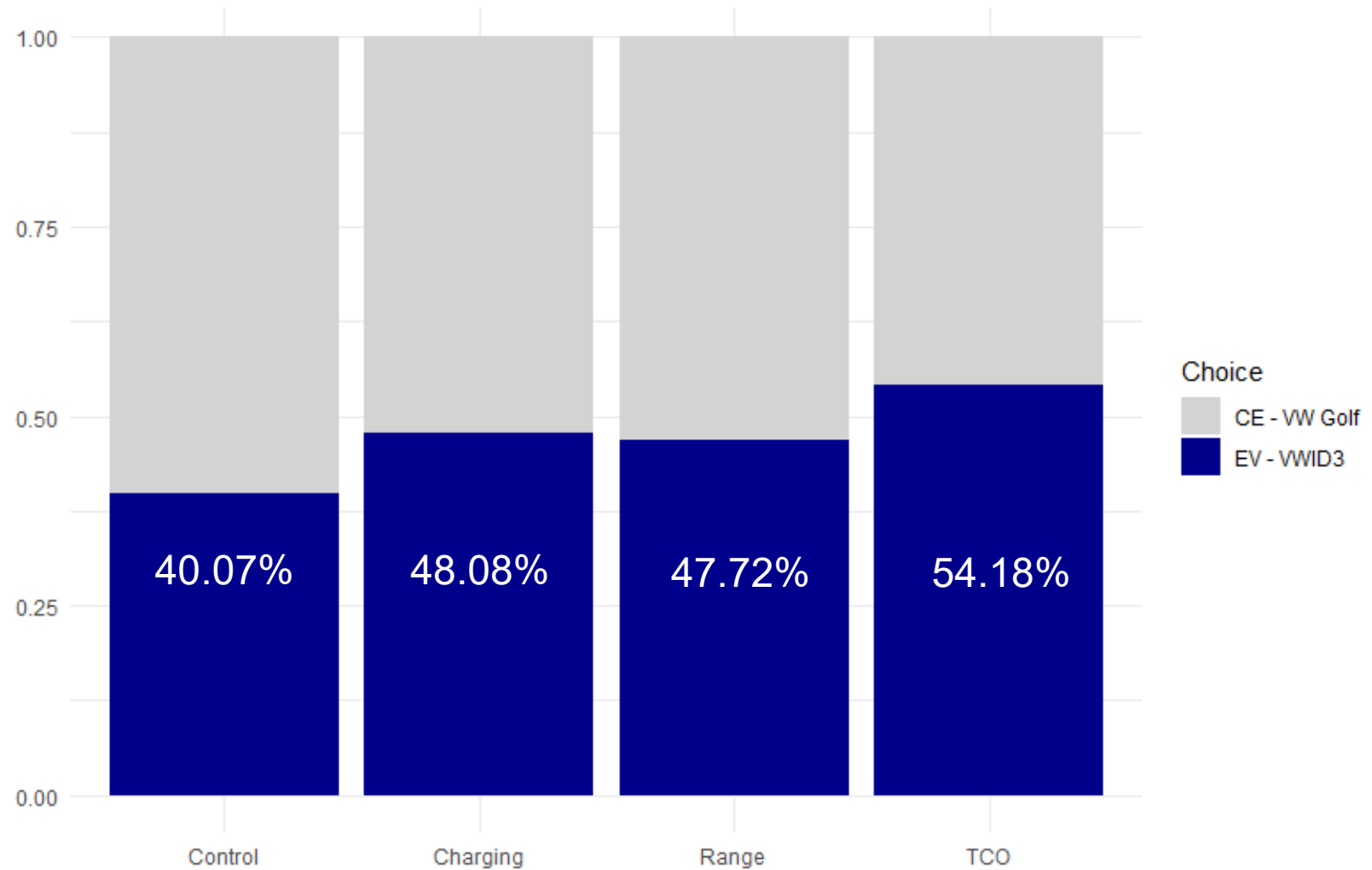
Compatibility bias: Charging



Compatibility bias: TCO



Results from RCT



Regression Results

Model Column	Treatment 1 only (1)	Treatment 2 only (2)	Treatment 3 only (3)	All three treatments (4)
Treatment 1	0.203** (0.066)			0.203** (0.066)
Treatment 2		0.194** (0.062)		0.194** (0.062)
Treatment 3			0.356*** (0.060)	0.356*** (0.060)
Observations	1507	1644	1742	3181

This table reports the coefficients of the models using probit methodology for the estimations. The dependent variable is a dummy variable for whether the respondent stated that he or she would choose a battery electric car. The regression sample includes 3181 observations. *, **, and *** respectively denote significance at 10%, 5%, and 1% levels.

	Treatment 1	Treatment 2	Treatment 3
Average marginal effect	0.080** (0.025)	0.076** (0.024)	0.141*** (0.023)

Note: The table reports the average treatment effects on the treated (the marginal effects corresponding to the coefficients on the treatment dummies in Table 3, calculated at the means of the independent variables) and standard errors (in parentheses). The results correspond to the coefficients from the probit estimation in column 4 of Table 3 that includes all three treatments and uses 3181 observations. *, **, and *** respectively denote significance at 10%, 5%, and 1% levels.

Conclusions

Take home message

- We confirmed the existence of **compatibility bias**
 - **Range Anxiety**
 - **Charging Anxiety**
 - **TCO Bias**
- All **personalized information** (not standardized) treatments (Charging, Range and TCO) significantly **increase EV uptake**
 - Stated choice experiment
 - Highest increase in TCO treatment
- **Policymakers, car manufacturers, and dealerships** could:
 - Complement conventional policy approaches (financial incentives, the development of charging infrastructure, and traffic regulations) with targeted information on compatibility biases

Thank you!

ubernardic@ethz.ch

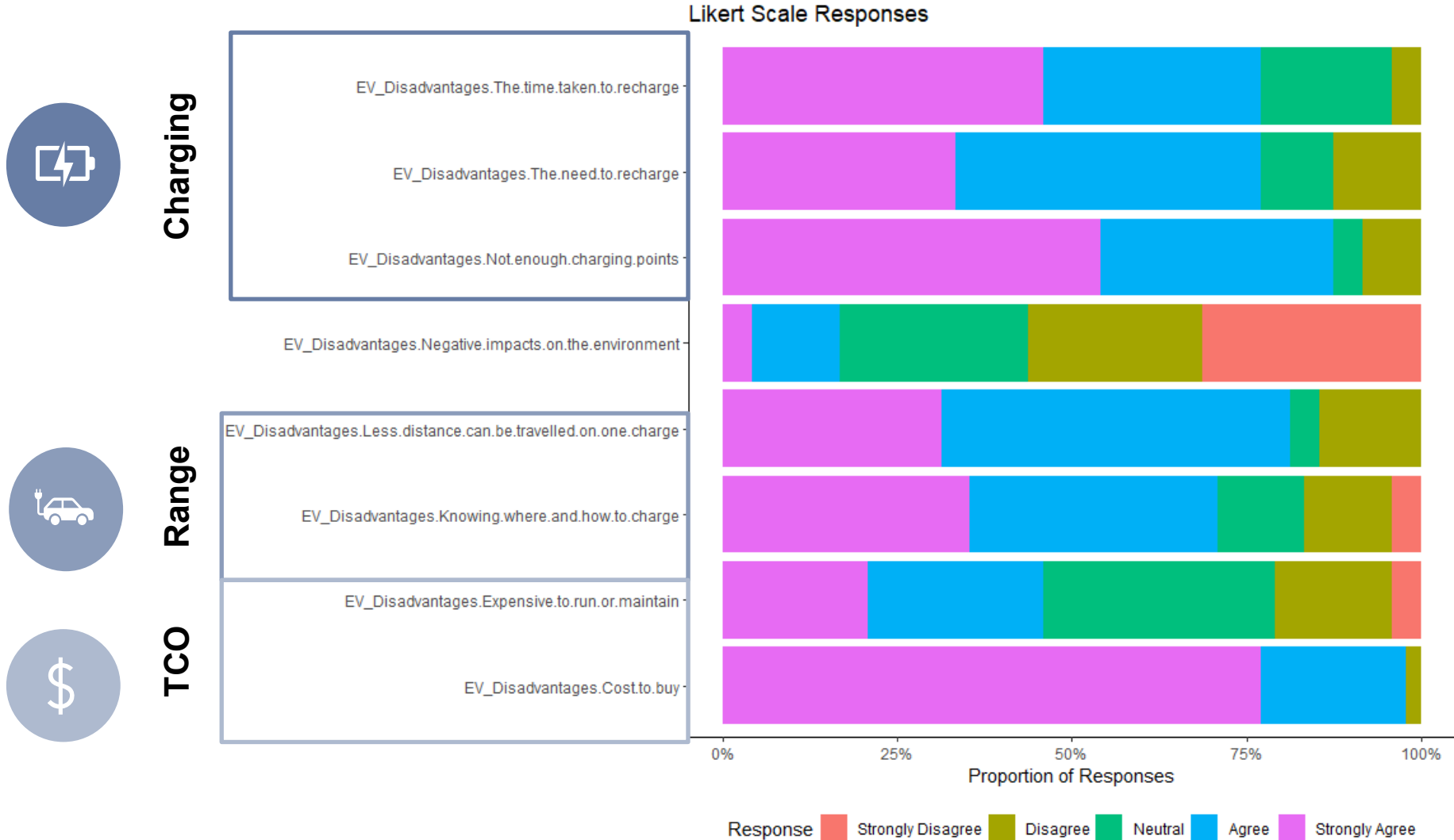


Policy Brief with Working Paper:



Appendix

Information and psychological barriers





The data from National Travel Survey Statistics were retrieved from: <https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy>

Number of vehicles: Total 4 760 848 passenger cars



Electric Car - Share of Trips

In the following, we would like for you to imagine that you owned an electric car in 2022 and that your driving behaviour remained the same. For each of the battery ranges presented below, please estimate the share of car trips that you could have covered without recharging. Car trips means all one-way car trips (i.e. outward and return trip counted separately), completed with you as the driver.

Please report the percentage of total car trips that you think you could have covered with the respective electric cars and battery ranges in 2022 (yearly). For example, if you could have covered all of your one-way trips in the year 2022 with a specific battery range, move the slider to 100. If you could only have covered 90% of all of your one-way trips in the year 2022 with a specific range move the slider to 90. Please adjust all sliders according to your responses and be aware that moving the first slider is necessary to proceed.

Electric car with a battery range of 420 miles:



50% of all trips could be covered with a battery range of 400 miles

Electric car with a battery range of 370 miles:



50% of all trips could be covered with a battery range of 370 miles

Electric car with a battery range of 320 miles:



50% of all trips could be covered with a battery range of 320 miles

Electric car with a battery range of 270 miles:



50% of all trips could be covered with a battery range of 270 miles

Electric car with a battery range of 220 miles:



50% of all trips could be covered with a battery range of 220 miles

Electric car with a battery range of 170 miles:

Electric Car - Charging

In the following, we would like for you to imagine that you owned an electric car in 2022 and that your driving behaviour remained the same. For each of the battery ranges presented below, please estimate how many times per week you think you would have had to charge an electric car with the following battery sizes.

For example, if you could have covered one-third of your weekly trips with a specific battery range and **have to** recharge three times, move the slider to 3. If you think, you would only need to recharge every two weeks, move the slider to 0.5. Please adjust all sliders according to your responses and be aware that moving the first slider is necessary to proceed.

Electric car with a battery range of 420 miles:



You would need to recharge an electric car with a battery range of 420 miles 5 times per week.

Electric car with a battery range of 370 miles:



You would need to recharge an electric car with a battery range of 370 miles 5 times per week.

Electric car with a battery range of 320 miles:



You would need to recharge an electric car with a battery range of 320 miles 5 times per week.

Electric car with a battery range of 270 miles:



You would need to recharge an electric car with a battery range of 270 miles 5 times per week.

Electric car with a battery range of 220 miles:



You would need to recharge an electric car with a battery range of 220 miles 5 times per week.

Electric car with a battery range of 170 miles:

Driving Diary - Work Week and Weekend

Please think about the length of car trips that you completed on a daily basis in an average work week and weekend in 2022 and fill in the following form.

Please note: Count outward and return trips separately - for example, if you drove 15 miles to your workplace on five workdays, please indicate the number 15 in the answer fields next to Monday till Friday for trip 1 and trip 2. Please note that a value is required for Trip 1 on Monday to continue. If you never travel on Mondays please input 0 for Trip 1.

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
Monday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Tuesday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Wednesday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Thursday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Friday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Sunday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Driving Diary - Long-Distance Trips

Now please think about additional long-distance car trips above 120 miles that you did in 2022 and fill in the following form.

Please note: Count outward and return trips separately - for example, if you went on vacation by car and drove 300 miles each way, please indicate the number 300 in the answer fields next to trip 1 and trip 2. Please note that a value is required for Trip 1 to continue. If there were no long-distance trips, please input 0 for Trip 1.

Long-distance trips	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Trip 7	Trip 8	Trip 9	Trip 10	Trip 11	Trip 12
	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Trip 13	Trip 14	Trip 15	Trip 16	Trip 17	Trip 18
	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Driving Diary - Total Distance Travelled in 2022

Now please indicate the total distance driven by car in 2022:

Continue

Weekly parking diary:

This is now your personal parking diary where, building on the answers to the driving diary, we would like to learn more about your parking behaviour in an average week. You will see below the table a feedback that is being updated as you fill in the table - with total hours parked and driving.

Please think again about your average week and how often you visit places such as your workplace, supermarkets or other places by car and for how many hours your car is parked there.

Please also think about how many times and for how long you park your car at home during the week and on weekends.

	Number of parking instances per Week	Average duration per parking instance
Parking at work	<input type="text"/> times	<input type="text"/> hours
Parking at a supermarket	<input type="text"/> times	<input type="text"/> hours
Parking at other places	<input type="text"/> times	<input type="text"/> hours
Parking at home during the <u>Week</u>	<input type="text"/> times	<input type="text"/> hours
Parking at home on <u>Weekends</u>	<input type="text"/> times	<input type="text"/> hours

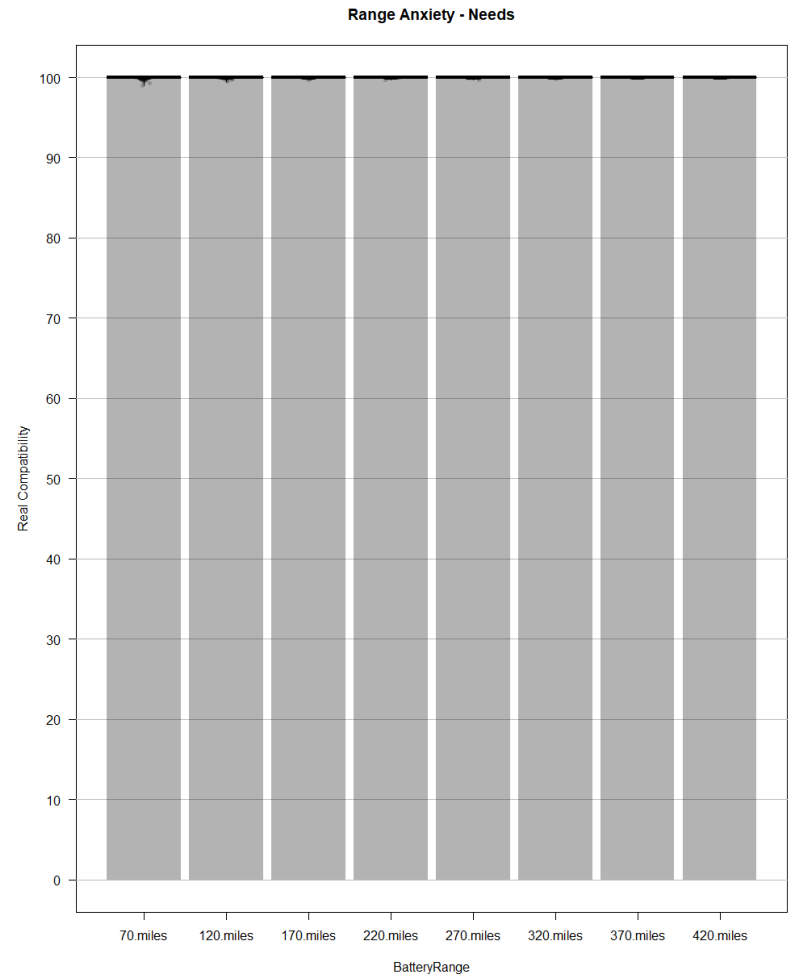
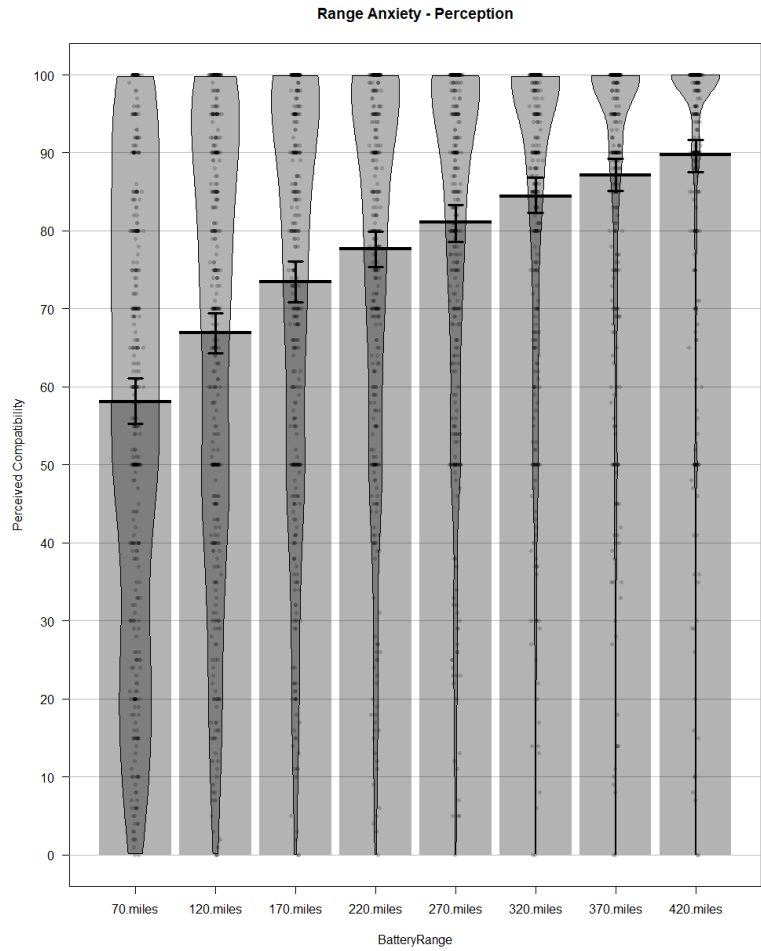
Feedback:

Your total hours parked are **0** hours.

This would result in **168** hours driving.

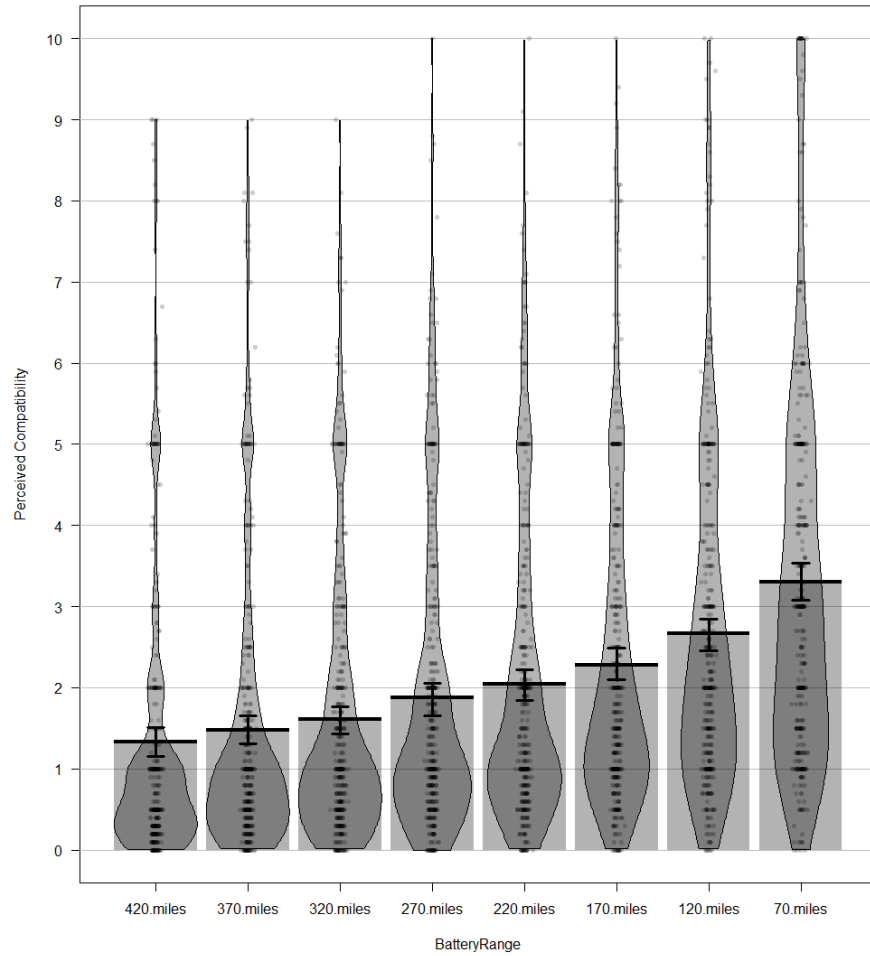
To be able to continue please note that total driving hours should be between 0 and 45 (the maximum driving hours allowed for professional drivers in the UK). Once you are between this range, the button Continue will appear.

Range Compatibility

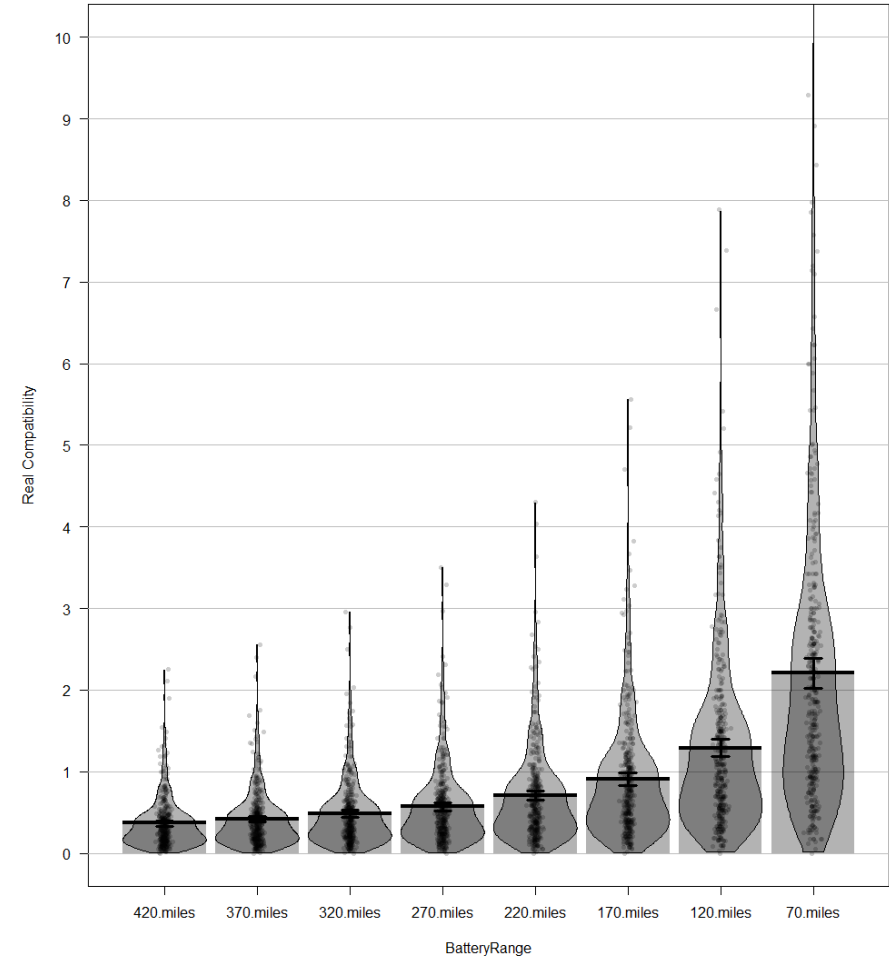


Charging Compatibility

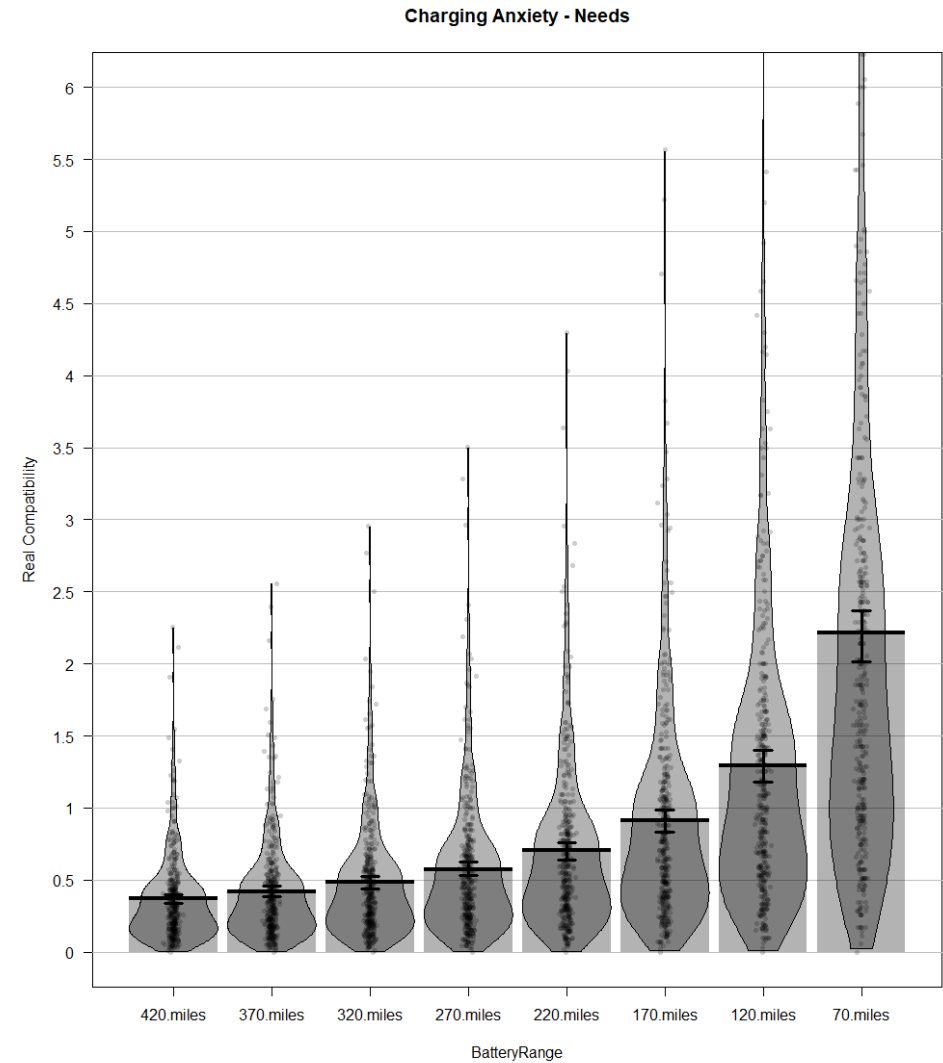
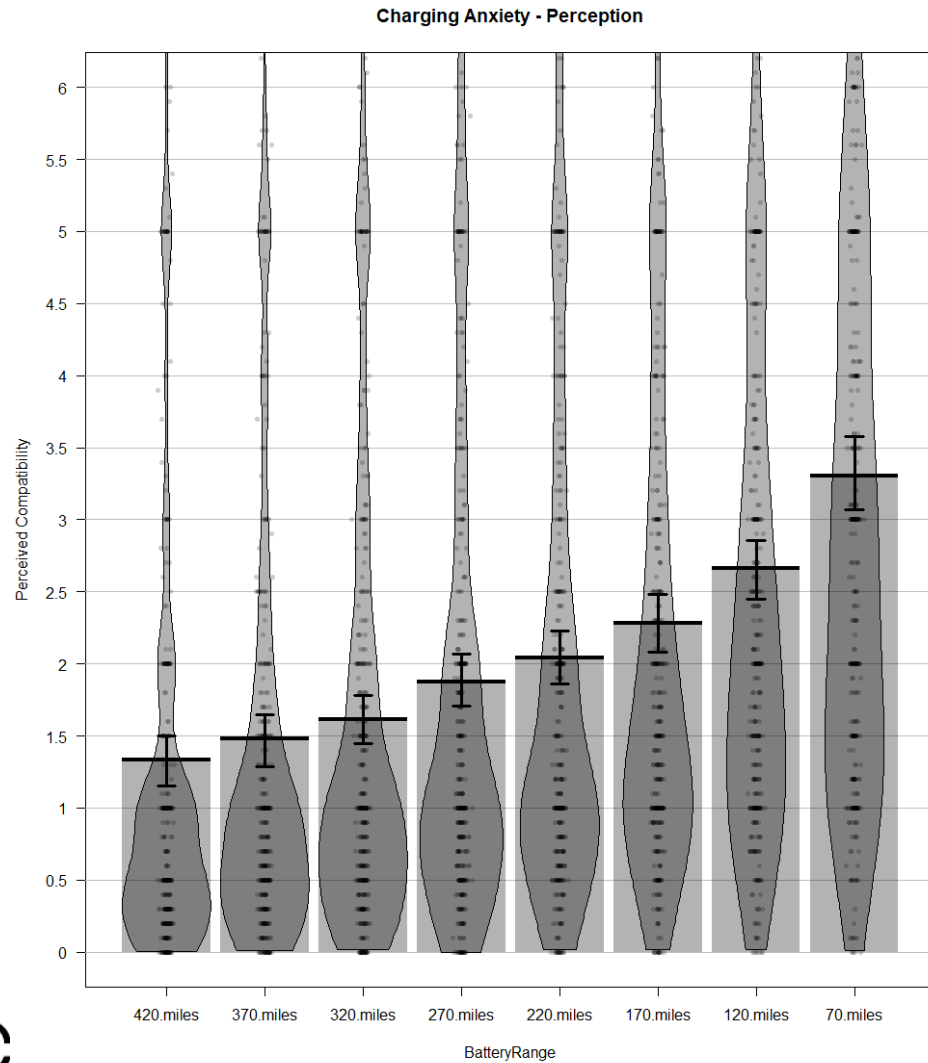
Charging Anxiety - Perception



Charging Anxiety - Needs



Charging Compatibility



TCO Compatibility

