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Counteracting electric vehicle range concern with a scalable behavioural intervention

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All-electric vehicles remain far from reaching the market share required to meaningfully reduce transportation-related CO_2 emissions. While financial and technological adoption barriers are increasingly being removed, psychological barriers remain insufficiently addressed. Here we show that car owners systematically underestimate the compatibility of available battery ranges with their annual mobility needs and that this underestimation is associated with increased demand for long battery ranges and reduced willingness to adopt electric vehicles. We tested a simple intervention to counteract this bias: providing tailored compatibility information reduced range concern and increased willingness to pay for electric vehicles with battery ranges between 60 and 240 miles, relative to a 50-mile-range baseline model. Compatibility information more strongly increased willingness to pay than did information about easy access to charging infrastructure, and it selectively increased willingness to pay for car owners who would derive greater financial benefits from adopting an electric vehicle. This scalable intervention may complement classical policy approaches to promote the electrification of mobility.

The adoption of battery electric vehicles (BEVs) is speeding up in many countries, which is an important step towards curbing the nearly 18% share of global CO_2 emissions currently accounted for by road traffic[1,2]. Increased adoption can be ascribed to a range of policies that aim to promote BEV adoption. Current policies are mainly based on providing financial incentives, creating a denser charging infrastructure and adapting traffic regulations, for instance, by providing privileged access to public transport lanes[3]. In particular, subsidies of BEV purchase prices have been shown to successfully counteract consumer tendencies to excessively weigh the higher BEV upfront costs and to discount future financial benefits[4].

Despite these achievements, the global share of BEVs is still far from its mass market objective. In 2020, electric vehicles (including hybrid-electric vehicles) accounted for only 1% of the global car stock, requiring almost exponential growth of sales to reach the 12% sustainable development target in 2030[5]. Concerns have been raised that financial incentives and technological improvements may be insufficient to convince the majority of hesitant consumers[6–8]. For example, financial incentives do not always increase BEV adoption, suggesting that other, non-financial factors may play a crucial role[9]. Similarly, recent research suggests that introducing a tax for CO_2 emissions will by itself not result in a large-scale uptake of BEVs[10]. With respect to technological improvements, the benefits of developing a dense public charging infrastructure have also been contested[11,12]. Consumers tend to prefer home charging[6,8], mainly due to currently still relatively long charging times[13]. Moreover, further increases in battery capacities may yield only a few additional car trips per single battery load[6].

What is more, larger batteries require more scarce resources such as lithium and cobalt for their production[14]. An increased demand for larger batteries may endanger the supply of these resources and exacerbate social injustice in the countries where they are extracted[15]. Alternative policy approaches may be needed to effectively increase BEV adoption while promoting sufficiency with respect to battery sizes. Promoting the use of smaller-sized batteries would reduce the burden on challenging reuse and recycling solutions[14,16].

Given that many financial and technological barriers are already being alleviated in many countries[3], behavioural interventions based on insights from psychology may complement the existing policies in the promotion of BEV adoption[10]. Many consumers are sceptical that the available BEV battery ranges can meet their mobility needs. Range concern—the worry that a given battery range will be insufficient to reach one's destination—is one of the major barriers to BEV adoption[6,8,17,18]. Consequently, consumers express strong preferences for long battery ranges[19] and require considerable range safety buffers to feel comfortable driving a BEV[20,21]. Indeed, the perceived compatibility of a given BEV with individual mobility needs and lifestyles seems to be one of the most important predictors of BEV purchase intentions and adoption[22–25].

Analyses of actual driving profiles, on the other hand, suggest that even BEVs with moderate battery ranges already meet most consumers' mobility needs[6]. Across Australia, China, the United States and European countries, research has found that more than 90% of individual mobility needs can be met with available and increasingly affordable BEV battery ranges such as 200 km[18,26–29]. Despite the scientific consensus that subjectively insufficient battery ranges constitute a barrier to BEV adoption[6,8,17,18], previous behaviourally informed interventions have mainly focused on the reduction of *situational range anxiety* when driving a BEV by providing first-hand BEV experiences through test drives, yielding either positive[30–33] or mixed effects[34,35]. In comparison, *anticipatory range concerns* that may limit consumer preference for BEVs before even considering to test or purchase a BEV[36] have remained relatively understudied. More importantly, no interventions exist that address range concern in an effective and scalable way.

The observed discrepancy between the subjectively perceived and the actual compatibility of electric vehicle range with consumer needs raises the question to what extent consumer perceptions may be biased by heuristic decision processes[37,38]. For instance, judgements and decisions are more strongly influenced by easily computable and comparable product attributes, such as absolute battery range, than by difficult-to-compare attributes, such as actual

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compatibility[39,40]. Thus, BEVs may be evaluated based on the comparison of their battery range with the (so far superior) range of petrol cars instead of the comparison of BEV battery range with one's actual needs. Moreover, decision makers have been found to be frequently and unconsciously influenced by the anchoring heuristic, whereby judgements tend to align with an initially provided reference value that serves as anchor, even if the anchor is irrelevant to the judgement at hand[41,42]. When evaluating a BEV battery range, the relatively high numerical value of its range in comparison with most daily trips may act as an anchor and increase the salience of long car trips in memory (for example, vacation trips). The resulting salience of exceptionally long car trips may then additionally contribute to a systematic underestimation of compatibility. Previous research supports the importance of accounting for seemingly irrelevant reference values in consumer preferences for alternative-fuel vehicles[43,44].

Systematic compatibility underestimations may increase the minimum battery range consumers deem necessary when considering the purchase of a BEV and may reduce consumers' overall willingness to adopt a BEV. Correcting this underestimation may therefore be a promising and presently untapped avenue to promote BEVs while at the same time avoiding the over-sizing of batteries. In the present work, we estimate the compatibility bias (that is, the discrepancy between perceived and actual compatibility with drivers' mobility needs) and determine its effect on BEV buying intentions and battery-range requirements. We then develop and test a behavioural intervention to counteract the compatibility bias. We identify reductions in range concern as an underlying mechanism of the effectiveness of the intervention and assess its effectiveness as a function of individuals' car operating costs. Finally, we compare the effectiveness of the compatibility intervention to a more conventional intervention that provides information about access to public charging infrastructure.

Compatibility perception and electric vehicle preferences

In studies 1a and 1b, participants from two representative samples of car owners in Germany ($N = 438$) and the United States ($N = 421$) estimated which proportion of their annual car trips they could complete with a given BEV battery range (that is, perceived compatibility; Supplementary Tables 1 and 2 provide sample characteristics). Eight battery-range levels were selected to cover most available battery ranges from 80 km to 400 km in the German sample and from 50 miles to 240 miles in the US sample. The lowest battery-range level corresponded to the somewhat outdated 2013 Nissan Leaf (50 miles), while the highest level corresponded to a 2019 Tesla Model 3 (240 miles; Supplementary Note 2). Participants moreover reported their driving behaviour during the previous year (2019) by indicating how often they completed car trips of different distances, regrouped in 15 bins ranging from 'less than 0.5 miles' to 'more than 240 miles' (Methods provide more details). The actual compatibility of BEV battery ranges with consumer needs was computed as the ratio of the number of car trips that could have been completed with a given battery range divided by the total of reported car trips (Methods and Supplementary Note 1). Finally, participants reported whether they intended to buy a BEV within the next ten years and indicated which battery range they would require to consider a BEV as an alternative to their current combustion engine car. We hypothesized that car owners systematically underestimate the compatibility of BEVs with their individual mobility needs and that the size of this bias is associated with lower buying intentions and higher battery-range requirements.

Figure 1 shows the perceived and the actual compatibility of BEV battery ranges with car owners' mobility needs. A paired sample t-test confirmed that car owners systematically underestimated compatibility in both samples. As expected, the average bias was larger than zero in both the German ($b = 29.62\%$, 95% confidence interval (CI) [28.47, 30.78], $P < .001$) and the US sample ($b = 32.28\%$, 95% CI [30.9, 33.67], $P < .001$) and reflected an underestimation of actual BEV compatibility of about 30%. As shown in Table 1, linear regression analysis revealed that the size of the bias was negatively associated with consumer intentions to adopt a BEV, both in the German ($b = -0.39 \pm 0.09$ standard error of the mean (s.e.m.), $P < .001$) and the US sample ($b = -0.46 \pm 0.10$ s.e.m., $P < .001$), when accounting for age, gender, household income, annual mileage and access to public transport as covariates (for results of an exogeneity check, see Supplementary Note 9). Similarly, the size of the bias was positively associated with battery-range requirements in Germany ($b = 32.97 \pm 10.91$ s.e.m., $P = .003$) and the US ($b = 23.78 \pm 10.43$ s.e.m., $P = .023$; Supplementary Note 5 and Supplementary Tables 3 and 4 show results including perceived and actual compatibility as separate predictors). While these results provide merely correlational evidence on the relationship between the compatibility bias and consumer preferences, Study 2 was designed as an experiment to allow causal inferences.

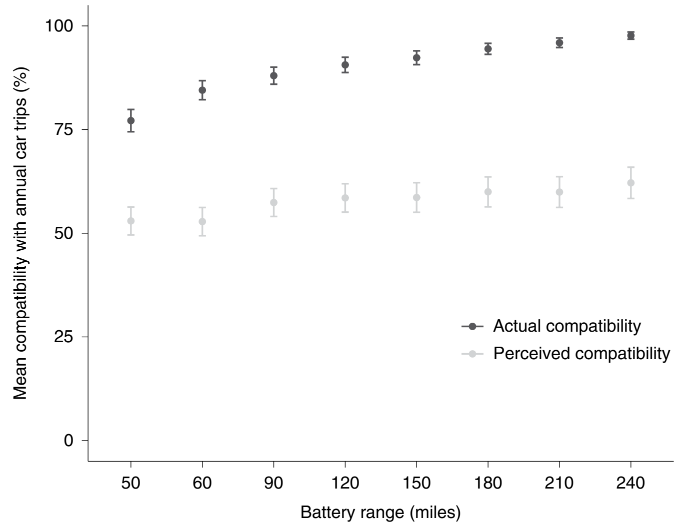

Fig. 1 | Perceived and actual compatibility of BEVs with annual mobility needs. In a representative sample of US car owners, perception of the compatibility of BEVs with car owners' mobility needs was systematically biased towards an underestimation of actual compatibility ($N = 421$; study 1b). A similar bias was observed in a representative car owner sample from Germany (Supplementary Fig. 1). Data are presented as mean values with error bars indicating the 95% confidence intervals of the mean.

Intervention effects of providing compatibility information

In studies 2a and 2b, we designed and implemented an intervention aiming to correct the compatibility bias and reduce range concern by providing new samples of car owners from Germany ($N = 279$) and the United States ($N = 999$) with tailored information about the actual compatibility of BEV battery ranges with their annual mobility needs. Individually tailored information has been shown to increase consumer preferences in diverse contexts, such as access to public transport in residential choices[45] and lower energy consumption more broadly[46]. The compatibility information was computed based on respondents' self-reported driving behaviour using the same measures as in studies 1a and 1b. Participants were then presented with a number of BEVs with battery ranges between 60 miles and 240 miles and indicated their willingness to pay for each BEV relative to a 50-mile baseline model (for details and an example of the task, see Methods and Supplementary Fig. 3; for a discussion of the preference measure, see Supplementary Note 3). In the control condition, participants received information

Table 1 | The results of linear regressions predicting electric vehicle buying intentions and battery-range requirements

Dependent variable	Study 1a		Study 1b		Study 1a		Study 1b	
	Buying intentions				Required battery range			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	4.16***	3.49***	3.48***	3.25***	360.94***	308.43***	256.29***	257.88***
Compatibility bias	−0.51***	−0.39***	−0.55***	−0.46***	31.75**	32.97**	15.75	23.78*
Age		−0.57***		−0.60***		34.78**		43.99***
Gender		0.47*		0.17		29.50		−9.5
Household income		0.40***		0.28**		19.27		28.12**
Annual mileage		−0.08		−0.07		41.56***		24.8*
Access to public transport		0.23*		−0.16		−6.03		7.52

Note: linear regression results based on two representative car owner samples from Germany (study 1a) and the United States (study 1b). Biased perception of the compatibility of an electric vehicle with car owners' mobility needs predicted lower intentions to buy an electric vehicle (left half of the table) and higher battery-range requirements (right half of the table). The *t*-tests of the regression coefficients were two sided, and no adjustments for multiple comparisons were made. The dependent variable *intention to adopt an electric vehicle within the upcoming 10 years* was measured on a scale from 1 = not at all to 7 = absolutely yes, while *battery range required of an electric vehicle to present an alternative to your current combustion engine car* was reported as numerical input in kilometres or miles (Methods). The compatibility bias was averaged across battery ranges within participants. All continuous predictors were *z*-standardized. More fine-grained analyses of the data, including exact *P* values of the regression coefficients are presented in Supplementary Tables 3–6. ***$P<.001$, **$P<.01$, *$P<.05$.

about battery range only, provided either in km (Germany) or miles (US). In the compatibility-intervention condition, participants were additionally provided with tailored information about the percentage of their annual car trips which they could complete with a given BEV without a charging stop. To compare the effectiveness of our intervention with a conventional policy aiming to increase preference for BEVs, in study 2b, a third group of participants was moreover presented with information about an infrastructure intervention[3]. Specifically, in addition to battery range, these participants were informed that the presented BEV would come with access to inner city parking and charging infrastructure (Methods and Supplementary Methods). Access to public charging infrastructure can generally be expected to increase consumer preference by reducing range concern[3,47]. However, we hypothesized that the compatibility information would more strongly increase car owners' willingness to pay compared with infrastructure information because it more specifically targets consumers' misperceptions of compatibility, which we suspect to be a major driver of range concern. Participants were moreover asked to what extent they believed that the provided battery-range information accurately reflected the battery range when driving outside of the standardized conditions under which battery-range estimates are usually obtained. Overall, car owners believed the provided battery-range information to be rather accurate (mean = 4.60, standard deviation = 1.34 on a scale from 1 to 7), with an analysis of variance indicating no differences between groups ($F(2,996)=0.96, P=0.38$).

Regression estimates of linear mixed-effects models confirmed that car owners reported higher willingness to pay for BEVs with longer battery ranges when provided with tailored compatibility information as compared to information about battery range only, both in the German sample ($b=829.4$, 95% CI $[32.5,+\infty]$, $P=0.045$, one-sided test) and the US sample ($b=2{,}237.4$, 95% CI $[1{,}482.3,+\infty]$, $P<0.001$, one-sided test; Fig. 2a; for model selection and specifications, see Methods and rows 4 and 8 of Supplementary Table 7). Providing information about access to inner city parking with charging infrastructure also increased willingness to pay in contrast to information about battery range, but only at marginal statistical significance ($b=658.1$, 95% CI $[-75.5,+\infty]$, $P=0.071$, one-sided test). Compatibility information more strongly increased willingness to pay than infrastructure information ($b=1{,}579.3$, 95% CI $[826.9,+\infty]$, $P<0.001$, one-sided test; ANOVA results for the effect of experimental group: $F(2,996)=12.31, P<0.001$).

To shed light on the psychological mechanisms underlying the impact of the compatibility intervention in study 2b, we additionally assessed range concern and its influence on car owners' willingness to pay. Range concern was measured as car owners' *worry to run out of battery before reaching their destination* when driving BEVs with different battery ranges. We hypothesized that range concern mediates the effect of the compatibility intervention (for the mediation model, see Fig. 2c).

As expected, participants reported lower range concern when provided with tailored compatibility information as compared with battery range only (Fig. 2b; $b=-0.51$, 95% CI $[-\infty,-0.31]$, $P<0.001$, one-sided test) or infrastructure information ($b=-0.42$, 95% CI $[-\infty,-0.22]$, $P<0.001$, one-sided test). Participants receiving compatibility information were less sensitive to decreases in battery range as compared with participants receiving information about battery range only ($b=0.18$, 95% CI $[0.129,0.235]$, $P<0.001$) and participants receiving infrastructure information ($b=0.19$, 95% CI $[0.137,0.243]$, $P<0.001$; Supplementary Note 6 provides ANOVA results and Supplementary Table 7 provides model specifications). Mediation analyses supported the role of range concern as a potential mediator of the effect of the compatibility intervention on willingness to pay (indirect effect = 0.062, 95% CI $[0.023,0.101]$, $P=0.002$], 10,000 bootstrap samples; Fig. 2c). In contrast, range concern did not mediate the effect of the infrastructure intervention (indirect effect = 0.015, 95% CI $[-0.02,0.05]$, $P=0.422$], 10,000 bootstrap samples).

Intervention effects as a function of current car costs

Behavioural interventions targeting cognitive biases have raised concerns of patronizingly *nudging*[48] people towards a behaviour that is beneficial for society or the environment while ignoring their personal preferences or potential costs[49,50]. To address this concern, we investigated to what extent the effect of the compatibility intervention on car owners' willingness to pay aligned with individual financial costs and benefits of BEV adoption. Following previous work, we approximated car owners' total cost of owning their current combustion engine car (TCO) based on their fuel costs (that is, mileage × fuel consumption), depreciation costs (that is, purchase price × *b* (car age); see ref. [51]), repair, tax and insurance costs (Methods and Supplementary Note 4). High TCO mainly reflects high fuel costs, for which BEV efficiency advantages would yield the greatest individual savings. It moreover reflects the depreciation costs of car owners who recently purchased a higher priced car. These car owners may be able to more easily afford a BEV, which continue to be mostly available on the more expensive new (versus the lower-priced second-hand) car market. An intervention

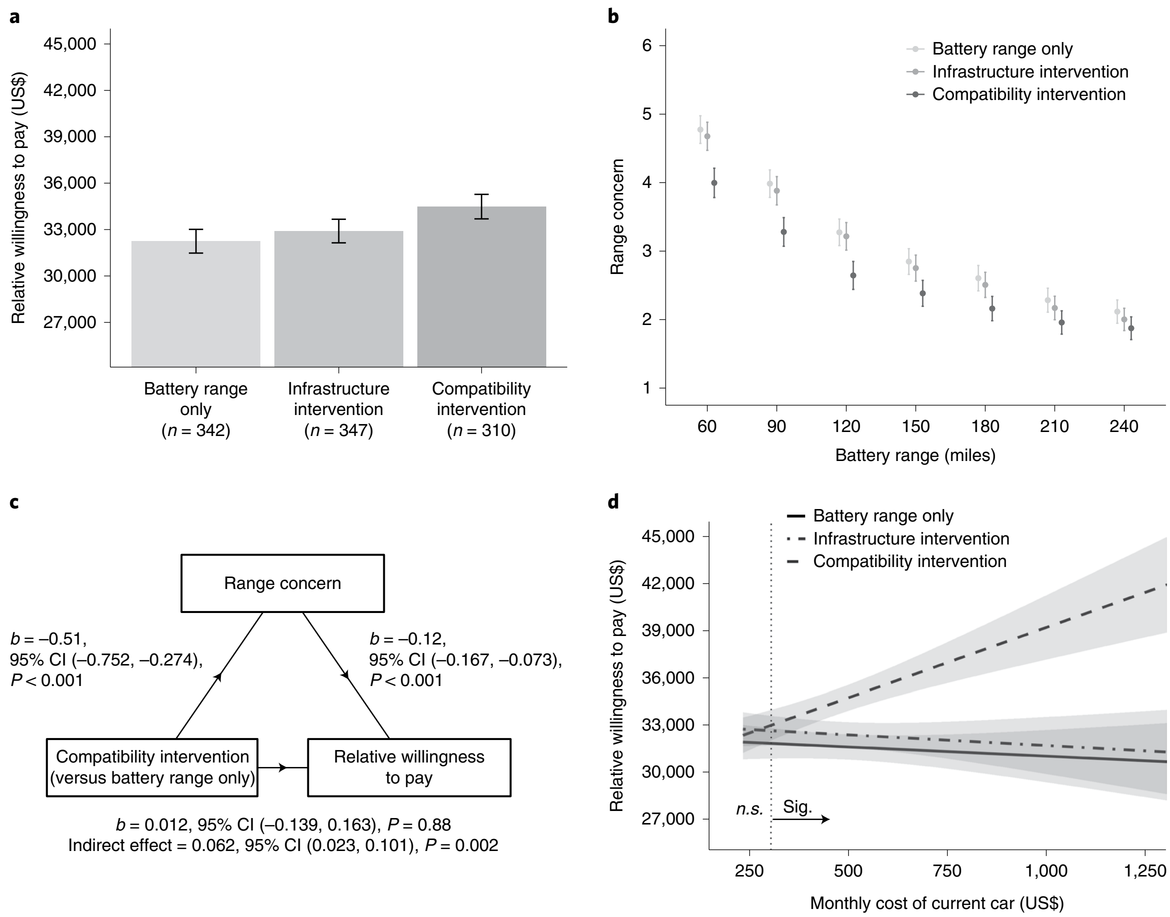

Fig. 2 | Effects of the compatibility and the infrastructure intervention on car owners' range concerns and relative willingness to pay. Data from a car owner sample recruited in the United States ($N = 999$; study 2b). **a**, Providing tailored compatibility information increased willingness to pay for BEVs with battery ranges between 60 miles and 240 miles relative to a 50-mile baseline model in contrast to providing battery-range information only, and more strongly so than combining battery-range information with information about access to inner city parking with charging infrastructure. **b**, The compatibility intervention decreased consumers' overall range concern, with a more pronounced effect for shorter battery ranges. **c**, A mediation analysis of the intervention effect on consumers' willingness to pay, including range concern as a mediator at the trial level, indicated that the effect of the compatibility intervention was driven by decreases in range concern (coefficient tests were based on two-sided estimations of quasi-Bayesian confidence intervals and were interpreted based on the non-adjusted statistical significance level of $P < 0.05$; Methods). **d**, The compatibility intervention more strongly increased relative willingness to pay for car owners with higher current total costs of owning a car and who would thus obtain higher financial benefits from adopting a BEV. Specifically, in contrast to battery-range information only, the compatibility intervention was increasingly effective for car owners with total current costs higher than US$374 (SD = 51; right of the dotted vertical line = interaction statistically significant (sig.); Supplementary Note 7). Conversely, there was no difference in willingness to pay between the battery range only and the compatibility-intervention group for car owners with total costs below this threshold (left of the dotted vertical line: interaction not statistically significant (n.s.)). Data are presented as mean values with error bars (**a**,**b**) and error bands (**d**), indicating the 95% confidence intervals of the mean. See Supplementary Fig. 2 for similar results for the German sample in study 2a.

that increases the willingness to pay of car owners with high TCO would thus align individual financial and environmental benefits, while increasing the willingness to pay of car owners with low TCO, for whom individual benefits were smaller, would be ethically questionable.

Compatibility information more strongly increased the willingness to pay of car owners with high TCO than for car owners with low TCO, both in the German ($b = 1{,}389.28$, 95% CI [384.23, 2,394.33], $P = 0.007$) and the US sample ($b = 2{,}089.8$, 95% CI [1,159.78, 3,019.86], $P < 0.001$; Fig. 2d). The effectiveness of infrastructure information did not vary in function of TCO ($b = -38.99$, 95% CI [−906.53, 828.55], $P = 0.93$; Supplementary Note 7 provides ANOVA results, and Supplementary Note 8 provides regression results including individual TCO components instead of TCO as predictors). In sum, the compatibility intervention presented here seems to specifically target consumers who may benefit most from owning a BEV.

Discussion

The present research demonstrates that providing car owners with tailored compatibility information based on their individual driving behaviour seems to be a viable means to reduce range concern, increase willingness to pay for BEVs with longer battery ranges and align financial and environmental benefits. The findings were robust across samples of German and US car owners, despite important variations in geography and related transportation energy requirements between both countries[52]. Providing compatibility information seems to counteract car owners' biased underestimations of the extent to which BEVs can meet their individual driving needs. Targeting this bias increased car owners' willingness to pay for BEVs with battery ranges between 60 miles and 240 miles in comparison with a 50-mile baseline model. An accurate perception of the compatibility of currently available BEV battery ranges with consumer needs may help avoid demand-driven developments of oversized BEV batteries.

Our findings contribute to the debate on whether battery-range limitations should be understood as a technical[19,53] or a psychological barrier[18,54]. In line with transportation research estimating that most mobility needs can already be met with moderate battery ranges[6,18,26–29], our results provide further evidence that limited battery range might to a large extent be a psychological barrier to BEV preference.

Correcting the compatibility bias may guide consumers towards more adequately sized batteries. The depletion of increasingly scarce resources needed to build BEV batteries[14] may be mitigated by a consumer demand that is based on more accurate compatibility perceptions. The compatibility intervention was particularly effective for car owners with high total costs of their current combustion engine car. Car owners for whom switching to a BEV would yield the lowest additional depreciation costs and the highest savings of fuel costs seem to be most receptive to the provision of compatibility information. This responds to ethical concerns raised with regard to behavioural interventions[49,50] and illustrates that the approach presented here has the potential to align private and public benefits in the combat of climate change[1,55].

The present research has some limitations. We estimated BEV compatibility based on car owners' self-reported driving and with a focus on trip compatibility instead of daily compatibility. Given that consumers continue to prefer overnight home charging[56], providing information about the daily compatibility of BEVs with individual mobility needs may be more relevant and potentially lead to even larger preference increases until fast-charging becomes more widely available[13] (Supplementary Note 1 provides a discussion of the compatibility measure). Replicating our research with GPS-tracked driving data would allow for a more precise estimation of daily compatibility and the compatibility bias. We, moreover, did not account for external factors that can impact battery range such as trip velocity profiles and ambient temperature[6]. Car owners' awareness of such range-reducing factors may justifiably contribute to lower perceptions of compatibility. However, despite pointing participants to the potential inaccuracy of battery-range information usually obtained under ideal conditions (Methods and Supplementary Methods), they judged the provided information to be fairly accurate, limiting the potential influence of range-reducing factors on compatibility perception. Moreover, our estimations of compatibility generally align with research explicitly taking velocity profiles and ambient temperature into account[6], further supporting the validity of our conclusions. Future research should disentangle which proportion of car owners' compatibility perception is due to the compatibility bias and which proportion represents the justified integration of external factors or individual needs for a battery safety buffer when actually driving a BEV[20].

We moreover elicited car owners' stated preferences in a hypothetical purchase scenario. This approach allows evaluating differences in car owners' willingness to pay between experimental groups but does not allow us to draw conclusions about car owners' absolute monetary valuations of BEVs. Additionally, this preference measure allows only limited conclusions about the effect of the compatibility intervention on BEV adoption, because increasing willingness to pay for BEVs with battery ranges between 60 miles and 240 miles relative to a 50-mile baseline model does not necessarily lead current owners of a petrol car to switch to a BEV. Experimental research directly investigating car owners' preferences for BEVs relative to a comparable petrol car may provide further insights into their willingness to adopt a BEV. Additionally, range concern may not be the only process underlying the effect of the compatibility intervention, and more normative influences such as car owners' willingness to adapt their driving habits may play an equally important role[24,57]. Future research should rely on revealed preferences to validate our findings. Research should moreover explore other psychological mechanisms underlying the compatibility intervention and investigate to what extent it can complement existing financial and infrastructure incentives to increase consumer preference in the real world.

The self-report approach used in the present research allows for a straightforward integration of tailored compatibility information into existing online tools by policymakers and industry. For instance, car manufacturers, retailers and car-sharing providers, whose markets increasingly move online[58,59], may easily provide compatibility information based on consumers' information about their habitual driving. While resulting privacy concerns may be addressed by data encryption, consumers' trust and use of compatibility information may vary as a function of the stakeholder that communicates the information. The analysis of click rates of BEV car models or search patterns in field trials could provide important insights into the impact of compatibility information on consumer preference.

The effectiveness of the compatibility intervention developed here illustrates the potential of psychologically informed interventions to reduce BEV range concern on a large scale. Correcting the compatibility bias may complement conventional policy approaches, such as financial incentives, the development of charging infrastructure and traffic regulations to promote BEVs[3]. Despite their uncontested importance, conventional policies tend to be costly and may not be sufficient to ensure a fast and large-scale adoption of BEVs[6,7,10]. Consequently, addressing major behavioural barriers, such as range concern and car owners' willingness to adapt their driving habits[57] may become decisive.

Methods

Data collection and analytic approach. The sample sizes for studies 1a, 1b and 2a were determined based on similar research on consumer misperceptions of the energy consumption related to food and household appliances[60]. The sample size for study 2b was determined to be at least twice the sample size of study 2a per experimental group to allow for a sufficiently powered replication and extension. All data collection took place online and was completed between 13 July 2020 and 15 January 2021. We used multiple linear regression for all analyses of single-measure outcomes and mixed-effect linear models for the analyses of the repeated preference and range concern outcomes in studies 2a and 2b. The statistical assumptions for the use of a linear regression approach were met. Additionally, the analyses of buying intentions in studies 1a and 1b were validated using ordinal regression analysis (Supplementary Tables 5 and 6). Statistical tests were computed one sided to test directional hypotheses and two sided to test non-directional hypotheses using an alpha level of 0.05. The random effects structures of the mixed-effects models were selected based on the best global model fit as indicated by the Bayesian and Akaike's Information Criterion (Supplementary Table 7). We included attention checks that reminded participants to be attentive to convert 'satisficing participants into diligent participants'[61], and conservatively used all available data wherever possible.

Studies 1a and 1b. *Participants.* Two online samples of car owners were recruited in Germany ($N=512$) and the United States ($N=512$) via market research institutes. Both samples were representative for the respective car owner population with regards to age, gender and household income (Supplementary Tables 1 and 2). Quotas were ensured by the market research institutes. German participants' ages ranged from 19 to 85 with a mean of 49.01 (SD = 16.7), US participants' ages ranged from 18 to 92 years with a mean of 48.14 (SD = 17.3). 48.4% (Germany) and 49.8% (US) of participants were female. The median annual gross household income reported by participants was €30,000 to €42,000 in the German sample and US$50,000 to US$74,999 in the US sample (Supplementary Table 2 provides the ethnic composition).

Procedure. After providing demographic information, participants were asked to estimate which percentage of their car trips in 2019 would have been feasible with a BEV without having to stop for recharging (perceived compatibility). Participants were asked to consider all one-way car trips for their estimation, outward and return trips separately, and were provided with the information that a BEV is exclusively powered by its built-in battery. Participants completed their estimations for BEVs with battery ranges of 80 km, 100 km, 150 km, 200 km, 250 km, 300 km, 350 km and 400 km in study 1a and 50 miles, 60 miles, 90 miles, 120 miles, 150 miles, 180 miles, 210 miles and 240 miles in study 1b (on a scale from 0% (none of the car trips feasible) to 100% (all of the car trips feasible); Supplementary Note 2 provides details on the selection of the battery-range levels).

Next, participants reported their intention to buy a BEV within the next ten years on a scale from 1 = not at all to 7 = absolutely yes, indicated the range they would require of a BEV to consider it as an alternative to their current combustion engine car and completed an attention check. Buying intentions were elicited for a relatively long time horizon to provide participants with some room for consideration, because average car age in Germany in 2020 was 9.8 years (ref. [62]). Then, participants were asked to report the frequencies with which they had travelled the following distances with their car throughout the year 2019: shorter than 0.5 miles, 0.5 miles < 1 mile, 1 mile < 2 miles, 2 miles < 5 miles, 5 miles < 10 miles, 10 miles < 20 miles, 20 miles < 30 miles, 30 miles < 60 miles, 60 miles < 90 miles, 90 miles < 120 miles, 120 miles < 150 miles, 150 miles < 180 miles, 180 miles < 210 miles, 210 miles < 240 miles and 240 miles and longer (shorter than 0.5 km to 400 km and longer in study 1a). Bin sizes of trip distances were determined based on national travel surveys in Germany[63] and the United States[64]. Participants were asked to carefully answer the questions while considering shorter, daily car trips and longer, less frequent trips, such as vacations. Additionally, to facilitate their estimations, participants were reminded that one year consists of 52 weeks with five working days each and of all federal public holidays. Finally, participants were asked to count outward and return trips separately and were provided with an example answer of a person commuting 15 miles to work for five days a week over one year (Supplementary Methods provide the exact stimuli). Participants were thanked and compensated with US$2 for their participation.

Analysis. Participants who reported not having completed any car trips in 2019 or estimated the amount of their 2019 car trips that could be completed with a BEV to be 0% across all battery ranges were excluded from the analysis ($n = 74$ in study 1a and $n = 91$ in study 1b) to ensure that only car owners who actively use their car were included and to avoid including car owners reporting zero estimates of perceived compatibility, which would have contaminated the results of the analyses. We dummy-coded exclusion to probe if exclusion was related to any of the measured demographic variables, which would have reduced the representative nature of our data. Generalized linear regressions revealed that none of the demographic variables of age, gender and income (plus ethnic group in the US sample), predicted exclusion from the analysis with statistical significance (all P values > 0.05; Supplementary Tables 1 and 2).

For the remaining participants from Germany ($n = 438$) and the United States ($n = 421$), we computed the actual compatibility of BEVs as the proportion of car trips reported by participants that could be completed without charging (Supplementary Note 1). For example, the actual compatibility of a BEV with a battery range of 60 miles was computed by dividing the sum of all reported trip frequencies for distances shorter than 60 miles by the total sum of trip frequencies. Next, we computed each participant's compatibility bias by subtracting the actual compatibility from the perceived compatibility for each battery range. Finally, we introduced the mean compatibility bias of each participant as a predictor of intention to buy an electric vehicle and battery-range requirements in a linear regression, while controlling for age, gender, income, annual mileage, and the connection of participants' homes to public transport services (Table 1; Supplementary Tables 5 and 6 provide ordinal regression results). Additionally, we computed the same linear regression models including perceived and actual compatibility as predictors instead of their difference—the compatibility bias (Supplementary Note 5 and Supplementary Tables 3 and 4).

Study 2a. *Participants.* An online sample of car owners from Germany was recruited via a market research institute ($N = 280$). Participants' ages ranged from 18 years to 80 years with a mean of 44.9 years (SD = 15.1), and 52.1% were female.

Procedure. After reporting their age and gender, participants provided information about their current car. Participants were asked to report the age, original purchase price and fuel consumption of their current car. In case they were unsure about some of the required information, they were instructed to consult their documents or another member of their household to obtain the information. Participants then completed an attention check[61] and, applying the same procedure as in Study 1, reported the frequencies of their car trips in 2019. Next, participants were introduced to the relative-willingness-to-pay task (Supplementary Fig. 3 and Supplementary Methods). They were asked to imagine that they had decided to replace their current car with a BEV that was available with different battery ranges. Participants were asked to indicate their relative willingness to pay (RWTP) for increasing battery ranges given that the most basic configuration of the BEV has a battery range of 80 km and costs €20,000. To familiarize participants with the task, they were presented with an example of the basic model indicating its battery range and purchase price. Participants were then randomly assigned to either the battery range-only condition or the compatibility-intervention condition. Accordingly, they reported their RWTP either based on information about battery range only ($n = 141$) or based on tailored compatibility information in addition to battery range ($n = 138$). The compatibility information consisted of the percent of individual annual car trips that could be completed with a given battery range without a charging stop. Participants reported their maximum buying price on a slider ranging from €20,000 to €40,000. They completed a total of seven trials with battery ranges of 100 km, 150 km, 200 km, 250 km, 300 km, 350 km and 400 km, which were presented on separate pages (Supplementary Note 2 and Supplementary Methods). Finally, participants were thanked and compensated with €2.5.

Analysis. One participant who reported not having completed any car trips in 2019 had to be excluded from the analysis, leaving a final sample of $N = 279$. We confirmed that random assignment to experimental groups was successful by comparing the distributions of age, gender, annual mileage and monthly vehicle depreciation costs across conditions, which did not show any statistically significant differences (all P values > 0.52; Supplementary Table 8). The main analysis consisted of a linear mixed-effect model including a random intercept for subjects and a random slope for battery range and fixed effects for experimental group and battery range (Supplementary Table 7). We computed the TCO of the current car of each participant as a potential moderator of the intervention effect. To this end, we computed the running costs by multiplying the total annual mileage of participants with the fuel consumption of their car and current fuel prices. Depreciation costs were calculated by taking into account the original purchase price and the age of participants' cars. Finally, we approximated tax, insurance and maintenance costs (Supplementary Note 4 provides details on the computation and the exclusion of statistical outliers in the self reports of annual mileage). We then added TCO and the interaction of TCO and the experimental group as fixed effects into the analysis (Supplementary Note 7 provides the model specifications and results, including covariates). To decompose the overall interaction of TCO and the experimental group, we additionally re-ran the analyses, replacing TCO with its components as predictors of willingness to pay (Supplementary Note 8).

Study 2b. *Participants.* An online sample of car owners from the United States was recruited via Prolific Academic ($N = 1{,}000$). Participants' ages ranged from 18 years to 84 years with a mean of 37.5 years (SD = 12.8), and 52.2% were female.

Procedure. The procedure was similar to study 2a. We adapted language and units to the US context, added the infrastructure intervention and additionally measured range concern as a potential mediator of the effect of the compatibility intervention on preference. In the infrastructure intervention, participants were informed that the presented BEVs grant access to inner city parking with charging infrastructure in addition to information about the battery range (Supplementary Methods provide the used stimuli). Participants were randomly assigned to either the battery range-only control group ($n = 342$), the compatibility-intervention condition ($n = 310$) or the infrastructure-intervention condition ($n = 347$). Successful random assignment to the experimental groups was again confirmed by comparing the distributions of age, gender, annual mileage and monthly vehicle depreciation costs, which did not show any statistically significant differences (all P values > 0.19; Supplementary Table 8). In all groups, range concern (that is, worry to run out of battery before reaching one's destination) was measured on a scale from 1 = not worried at all to 7 = very much worried, after completing the same RWTP tasks as in study 2a. Although the term *range anxiety* has also been used in this context, our terminology accounts for the distinction between situational range anxiety when driving a BEV[65] and range concerns before even testing or purchasing a BEV[36]. Finally, belief in the accuracy of the battery-range information was measured on a scale from 1 = not accurate at all to 7 = absolutely accurate, while highlighting that its standardized estimation cannot take into account all variations in real-life driving (Supplementary Methods). Participants were thanked and compensated with 1.5£.

Analysis. One participant who reported not having completed any car trips in 2019 was excluded from the analysis, leaving a final sample of $N = 999$. All analyses were identical to study 2a, with the exception of the analyses of range concern as a potential mediator of the compatibility intervention. Range concern was introduced as a level 1 mediator of the effect of the compatibility and the infrastructure intervention on RWTP. Coefficients and quasi-Bayesian confidence intervals were estimated based on 10,000 bootstrap samples, using the 'mediation' package in R[66]. Figure 2c provides the mediation model.

Generalizability. To avoid potential unequal distributions of sample characteristics across experimental groups, in studies 2a and 2b, we recruited from more homogeneous but less representative car owner populations. While recruiting from these populations allowed for the experimental evaluation of the effect of the compatibility intervention (Supplementary Table 8), it may present a limitation to the generalizability of our results. The age distributions of car owners in studies 2a and 2b were somewhat skewed towards younger individuals in comparison to national census data (Supplementary Tables 1 and 2). This discrepancy and other potential deviations from representativeness that we could not evaluate based on our data may reduce the extent to which our findings can be generalized for all car owners in the United States and Germany. However, the replication of our findings across two samples with car owners in the highly different contexts of the United States and Germany support the generalizability of our findings.

Ethics statement. This research was approved by the ethics commission of the Faculty of Psychology and the Educational Sciences of the University of Geneva, Geneva, Switzerland. Informed consent was obtained from all participants.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability
All data are publicly available at https://doi.org/10.17605/OSF.IO/8YZPF.

Code availability
The code used to generate the results and figures is publicly available at https://doi.org/10.17605/OSF.IO/8YZPF.

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Author contributions
M.H, U.J.J.H. and T.B. designed the research. M.H. collected and analysed the data. M.H, U.J.J.H. and T.B. wrote the paper.

Competing interests
The authors declare no competing interests.

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☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
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Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	We used the web-based survey platform provided by SoSci Survey GmbH for building all surveys. Online subject recruitment was realized in collaboration with two market research institutes based in Germany (Consumer Fieldwork GmbH and respondi AG; Study 1a, 1b, and 2a) and using the participant panel provided by Prolific Academics Ltd (Study 2b).
Data analysis	All analyses were conducted using the free software environment R Studio for statistical computing and graphics (version 1.4.1103; using R version 4.1.0). The following packages were used: Rmisc (version 1.5); dplyr (version 1.0.6); tidyr (version 1.1.3); ggplot2 (version 3.3.5); ordinal (version 2019.12-10); lme4 (version 1.1-27); lmerTest (version 3.1-3); cowplot (version 1.1.1); mediation (version 4.5.0); ivreg (version 0.6-1); modelsummary (version 0.9.5); interactions (version 1.1.5) gridGraphics (version 0.5-1) The analysis code is publicly available at doi.org/10.17605/OSF.IO/8YZPF.

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Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Studies 1a and 1b are quantitative correlational, Study 2a and 2b are quantitative experimental.
Research sample	Participants in Study 1a (N = 438; Mean age: 49.01 years, SD = 16.7; 48.4% female) and 2a (N = 279; Mean age: 44.9 years, SD = 15.1; 52.1% female) were adult car owners from Germany, and participants in Study 1b (N = 421; Mean age: 48.14 years, SD = 17.3; 49.8% female) and 2b (N = 999; Mean age: 37.5 years, SD = 12.8; 52.2% female) were adult car owners from the U.S.. The samples of Study 1a and Study 1b were representative of the car owner populations in Germany and the U.S. with respect to age, gender, and household income. The samples were chosen to allow the generalization of our findings to car owners in general. In Study 2a and 2b we did not aim for representative samples, because this would have likely led to unequal distribution of infrequent participant characteristics (e.g., low income) across experimental conditions.
Sampling strategy	Participants were randomly assigned to condition. The sample sizes of study 1a, 1b, and 2a were determined based on similar past work (Camilleri et al, 2019, Nat.Clim.Change). The sample size of study 2b was determined to be at least double the sample size for each condition as in Study 2a, to allow for a sufficiently powered replication and extension.
Data collection	Participants completed the study online on their computer. The researcher was not present during data collection.
Timing	Data collection took place from 14.07.20 to 21.07.20 (Study 2a), 03.11.20 to 13.11.20 (Study 1a), 16.11.20 to 08.12.20 (Study 1b), and 14.01.2021 to 15.01.2021 (Study 2b).
Data exclusions	In Study 1a and 1b, we considered participants who reported not having completed any car trips in 2019 or estimated the compatibility of electric vehicles with their driving needs to be 0% for all battery ranges as non-drivers or not having followed the instructions, and thus excluded them (n = 74 and n = 91, respectively). In Study 2a and 2b, one participant in each study reported not having completed any car trips in 2019 which also led to exclusion. Including these participants would have inflated the estimation of the compatibility bias (Study 1a and 1b) and would have not allowed the computation of the objective compatibility (all studies). The exclusion criteria were established after the data collections of Study 1a and 2a.
Non-participation	Participants self-selected to participate online after being contacted by the market research institutes (Study 1a, 1b, 2a) or after publication of the study on Prolific Academic (Study 2b). We cannot know how many potential participants viewed the call for recruitment but chose not to respond.
Randomization	Participants were randomly allocated to experimental condition in Study 2a and 2b. Study 1a and 1b did not employ an experimental design and did thus not require randomization.

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Materials & experimental systems

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☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☐	☒ Human research participants
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Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	See above.
Recruitment	Participants were recruited online. This limits the sample to adults who have access to a computer and to the internet. Past work using online recruitment strategy has found results that are similar to those found using in-person procedures. We do not know of any reason to suspect that computer ownership is likely to impact results. For Study 1a and 1b, we demonstrate representativeness of both samples with respect to age, gender, and household income (and ethnic group in Study 1b) of the German and U.S. car owner population. In Study 2b, participants were somewhat younger and more female than in the U.S. car owner population. Analyses accounted for all sociodemographic measures available in the respective data sets.
Ethics oversight	This research was approved by the Ethics commission of the Faculty of Psychology and the Educational Sciences of the University of Geneva, Geneva, Switzerland.

Note that full information on the approval of the study protocol must also be provided in the manuscript.