Article III

Knowledge, Information or Configuration – An Analysis of Consumer Powertrain Choice in Germany

Andreas Collet

University of St.Gallen

andreas.collet@unisg.ch

Jannis Linke

University of St.Gallen

jannis.linke@unisg.ch

Abstract

The uptake of battery electric vehicles (BEVs) is among the measures to decrease greenhouse gas (GHG) emissions in the global transport sector. However, the overall demand for BEVs is limited. Insufficient research has focused on the influence of BEV knowledge on consumer powertrain choice and how information on BEVs affects consumer decisions. Furthermore, research examining the influence of BEV knowledge and information on product configuration is scarce. This article examines these issues through a survey of 746 participants in Germany who were interested in buying a new car within the next 3 years. The results suggested that with increasing consumer knowledge of BEVs, the importance of certain product attributes increases. In addition, having BEV-related information does not necessarily promote BEV uptake, as also partly reflected in product configuration. Instead, emotions and habits appear to play important roles in powertrain choice. To minimise GHG emissions from the transport sector by accelerating the uptake of BEVs, manufacturers and policymakers should therefore proactively address consumers' experiences, habits and emotions regarding internal combustion engine vehicles (ICEVs).

Keywords: *battery electric vehicles, knowledge, information, powertrain choice, car purchase, BEV uptake*

1 Introduction

How to accelerate the electrification of the global transport sector remains a matter of interest among industry, policymakers and civil society (Corradi et al., 2023; Hainsch, 2023). Because the transport sector accounts for almost a quarter of global greenhouse gas (GHG) emissions (IPCC, 2023), the electrification of the transport sector, particularly of conventional passenger cars and vans, is considered a critical lever to decrease GHG emissions and combat climate change (Dumortier et al., 2022). Therefore, industry and policymakers have attempted to accelerate the transition to battery electric vehicles (BEVs). For instance, a variety of subsidies have been provided to manufacturers (Becker, 2017) or consumers (BMWK, 2023), and funds have been directed to the development of the necessary charging infrastructure (BMDV, 2022). In addition, the European Commission had banned the sale of new internal combustion engine vehicles (ICEVs) from 2035 onwards (COM, 2022). Nevertheless, global GHG emissions, particularly CO_2 emissions, from the transport sector have constantly increased, except the Covid 19-pandemic years (IEA, 2023a). Despite information campaigns on BEVs (Haustein et al., 2021), and recent technological progress in vehicle range and expansion of the charging infrastructure (Bundesnetzagentur, 2024; Greiner et al., 2020), the demand for BEVs, particularly in developed countries, has lagged behind expectations (Anastasiadou & Gavanas, 2022; Yang et al., 2023). Notably, in Germany, the European Union's largest car market, the target of 1 million BEVs by 2020 has not been met by a wide margin (Brandau, 2021), and the target of 15 million BEVs by 2030 is not likely to be met (Piller, 2024). With the proliferation of BEVs, research has identified the drivers and barriers that consumers encounter in adapting to BEVs (e.g., Li et al., 2017), such as better (fast-)charging infrastructure (e.g., Hardman et al., 2018), longer BEV ranges (e.g., Rainieri et al., 2023) and lower BEV purchase prices (e.g., Corradi et al., 2023). In addition, positive perceived environmental benefits of BEVs (Sierzchula, 2014) and attitudes have been found to have similar effects (Wicki, Brückmann, Quoss, et al., 2022). However, BEV technology is already sufficient to cover approximately 87% of all journeys (Melliger et al., 2018; Needell et al., 2016). In addition, BEVs in carsharing, a low involvement product, face similar rejection by consumers (Gomes & White, 2024). These findings may indicate that consumers, regardless of the use case, continue to lack information regarding the utility of BEVs.

Research analysing the effects of BEV knowledge on powertrain choice is lacking (Brückmann, 2022b). Although many consumers cite limited range and charging infrastructure, and high purchase price, as barriers to BEV acceptance (Corradi et al., 2023) it remains unclear, whether consumers cited these factors because they have been exposed to these issues before, e.g. through their own experiences (Axsen et al., 2017; Rajper & Albrecht, 2020). In addition, several studies analysing factors influencing BEV purchase have examined only a limited number of influencing factors (e.g., Higueras-Castillo et al., 2021). Furthermore, the influence of BEV-related information on powertrain choice and whether consumers still reject BEVs after product configuration have not been fully explored.

This article is aimed at better understanding the issues surrounding BEV uptake among potential car purchasers in Germany. To mitigate social desirability bias and to enrich methods in the field of BEVs, this article used indirect questioning. The survey is divided into three parts. In part 1, we analysed the weighting of individual factors influencing the purchase of a car regarding powertrain choice. In part 2, participants were randomly assigned to groups with or without exposure to BEV-related information, to investigate how this information influences powertrain choice and consumers' evaluation of the factors influencing car purchases. The group without exposure to BEV-related information served as a control. Finally, in part 3, to identify transition points to BEVs, we asked participants to configure selected product attributes and to describe barriers to purchasing BEVs in free text fields. All study parts were analysed according to participants' BEV knowledge and powertrain choice. The results were then compared with findings in the literature regarding consumer acceptance of BEVs.

The remainder of the article is structured as follows: section 2 provides an overview of the relevant literature, section 3 describes the method applied, section 4 presents the data, section 5 contains the results and discussion, and section 6 concludes with limitations and future research directions.

2 Literature Review

As BEVs have become increasingly widespread, research has focused on the drivers of, and barriers to, consumer use of these vehicles (e.g., Li et al., 2017; Wicki, Brückmann, Quoss, et al., 2022). To be consistent with other literature, this article uses the term 'acceptance' as applied by Wicki, Brückmann, Quoss, et al. (2022). Acceptance includes terms such as 'intention to buy a BEV', 'willingness to buy a BEV', 'intention to book a BEV', 'willingness to book a BEV', 'support for BEV use', 'willingness to pay for a BEV', 'intention to use a BEV' and 'general opinions about BEVs' (Wicki, Brückmann, Quoss, et al., 2022). Consumer use of BEVs can be classified according to terms such as product attributes, personal determinants and contextual determinants.[1]

Product attributes influencing consumer BEV uptake

Research has analysed BEV product attributes and their effects on consumer acceptance (e.g., Coffman et al., 2016; Li et al., 2017). Technological developments in BEVs have led to changes and improvements in product attribute levels over time (e.g., Forsythe et al., 2023; Greiner et al., 2020). The most frequently cited product attributes associated with consumer acceptance of BEVs are summarised below.

The *range* of BEVs with respect to those of ICEVs or HEVs is negatively associated with consumer acceptance of BEVs (Anastasiadou & Gavanas, 2022; Rainieri et al., 2023). Although the *range* of BEVs has increased steadily in recent years, current BEVs have a range of approximately 350–450 km (IEA, 2023b; TCS, 2024a), values lower than those of ICEVs or HEVs, which can reach 1,000 km (Akorli & Koch, 2023). Consequently, range anxiety exists among many consumers (Rainieri et al., 2023). However, Kölbl et al. (2013) has shown that, in some regions of Germany, the range of BEVs is already sufficient to cover 80%

[1] The focus of this article is on BEVs. As more consumers consider or purchase hybrid vehicles (Keohane et al., 2024), these choices will be included in future research. However, a literature section specifically on hybrid cars is not included herein. For the remainder of this article, all types of hybrid vehicles will be referred to as HEVs.

of all journeys. Similar values have been reported for Finland and Switzerland by Melliger et al. (2018) and for the United States by Needell et al. (2016). Higher *engine power* is generally preferred by consumers (Larson et al., 2014; She et al., 2017). Consumers often choose higher engine power for ICEVs for reasons that are not entirely rational, thus indicating their low weighting of fuel efficiency (Duncan, 2019; Turrentine & Kurani, 2007). BEVs generally have higher engine power than ICEVs, because of their higher efficiency (Li & Liu, 2019). Greater engine power leads to outcomes such as better acceleration (Mabit & Fosgerau, 2011) but does not significantly affect powertrain choice, because preferences regarding acceleration differ within the population. However, acceleration-oriented driving behaviour with correspondingly higher engine power drains the battery more quickly; consequently, consumers must adapt to the resulting battery depletion and the need for recharging (Helmbrecht et al., 2014; Rauh et al., 2015). Regenerative braking and the absence of engine noise are also factors influencing consumer choice behaviour (Labeye et al., 2016). These aspects partially explain why the *driving pleasure* is perceived to be lower for BEVs than ICEVs, (Graham-Rowe et al., 2012; Tchetchik et al., 2020). However, some research has indicated contrary results showing that BEVs can increase driving pleasure (Bühler et al., 2014; Haustein & Jensen, 2018). Notably, most BEVs in the large car segment are able to achieve their engine power and ranges because of the possibility of installing larger batteries (ADAC, 2024a). Moreover, manufacturers' profit margins remain higher in the large car segment than for smaller cars, thus resulting in a market gap for smaller BEVs with engine power comparable to those of ICEVs or HEVs (Dollinger, 2023). Consequently, the BEV product portfolios of the major manufacturers are not nearly as comprehensive as those of ICEVs; therefore, many consumers are unable to buy a BEV from their favourite brand in a particular *vehicle category* (ADAC, 2024c). For many consumers, buying a car is a personal and emotional matter, and is usually not a purely rational economic choice, thus emphasising the importance of brands (Sheller, 2004). Consequently, competition in the global automotive market in recent years has increased the pressure on manufacturers to meet a certain quality standard, because a car purchase is an investment that substantially exceeds the monthly incomes of most consumers (Hamzah & Pontes, 2022; Janoskova et al., 2021).

The issues of *charging infrastructure* and *charging time* are also major factors hindering consumer acceptance of BEVs (Hardman et al., 2018; Miele et al., 2020). The *charging infrastructure* is not yet as widespread as the traditional refuelling infrastructure for ICEVs (ADAC, 2021; EHI, 2024; Roth, 2024); this aspect is perceived negatively by consumers (Brückmann & Bernauer, 2023). In addition, consumers perceive the longer *charging times* for BEVs than ICEVs as a barrier (Higueras-Castillo et al., 2020). In recent years, the introduction of fast charging stations has accelerated (Bundesnetzagentur, 2024). However, unlike ICEVs, BEVs offer a possibility of home charging, e.g., via a wall box, thus providing consumers with additional freedom (Giménez-Gaydou et al., 2014; Liao et al., 2023; Scorrano et al., 2020). Overall, the extra *route planning* that BEVs currently required is considered negatively by consumers, who perceive BEVs as less convenient than ICEVs.

Price and *cost* also influence consumers' car purchase intentions (Austmann & Vigne, 2021; Brückmann, Willibald, et al., 2021). Currently, the average *purchase price* for a BEV in Germany is higher than that of an ICEV (€52,700 versus €45,000, respectively) (DAT, 2024; Tagesschau, 2023). The higher purchase price for BEVs negatively affects consumers' willingness to pay (Haustein & Jensen, 2018; Wicki, Brückmann, Quoss, et al., 2022). Many governments have therefore introduced *subsidies* to encourage consumers to buy BEVs, which have increased consumers’ intention to buy (Brückmann & Bernauer, 2020). Overall, the total cost of ownership (TCO) of a BEV is important, because BEVs confer a financial advantage after a threshold period of ownership (ADAC, 2024b; TCS, 2024c). In addition to the purchase price, the TCO includes the *costs of charging and refuelling*, as well as *maintenance and repair*, all of which influence consumers' purchasing decisions (Hess et al., 2011; Mandys, 2021; Wicki, Brückmann, & Bernauer, 2022; Wicki, Brückmann, Quoss, et al., 2022). Finally, *resale value* additionally affects consumers' car purchase decisions (Brückmann, Wicki, et al., 2021; Mandys, 2021). Because of the low market demand for BEVs, resale prices for BEVs have fallen (Gomes & White, 2024; Hartmann, 2024). Consequently, concerns have been raised among consumers, who worry that their BEVs might depreciate in value.

The *environmental impact* of BEVs also positively influences consumer acceptance of BEVs. Consumers cite the positive *environmental impact* of BEVs as a reason to choose a BEV (Sierzchula, 2014). However, many consumers have environmental concerns and reject BEVs because of their perceived poor carbon footprint, and concerns regarding the extraction and production conditions of the raw materials used in battery production (Haas & Globig, 2023; Sonnenholzner, 2024). These concerns persist, although research has shown that BEVs are more environmentally friendly over their lifetimes than ICEVs, particularly when they are charged with renewable energy (Ellingsen et al., 2016; Hoekstra, 2019).

Table 1 summarises the product attributes of BEV uptake described above.

Table 1
Factors influencing BEV Purchase

No.		**No.**	
1	Charging and refuelling cost	9	Possible ban on combustion vehicles
2	Charging and refuelling infrastructure	10	Preferred brand vehicle category
3	Charging and refuelling time	11	Production conditions
4	Driving pleasure	12	Purchase price
5	Engine power	13	Range
6	Environmental impact	14	Resale value
7	Government subsidies	15	Route planning for charging and refuelling
8	Maintenance and repair cost	16	Vehicle category

Note. Order of the factors influencing BEV purchase does not indicate ranking.

Contextual determinants influencing BEV uptake

Beyond product attributes, the contextual determinants of BEV acceptance have been researched.

The use case for BEVs is more suitable in urban than rural areas, because urban trips usually cover short distances, for which the range of current BEV models is more than sufficient (Ajanovic & Haas, 2016). In addition, higher mileage is detrimental to BEV acceptance, because consumers with higher mileage place greater value on BEV range (Hoen & Koetse, 2014). Because space is limited in urban areas, thus resulting in limited parking spaces, a public charging infrastructure is key to allow for BEV use (IEA, 2023b). In contrast, rural areas enable easy home charging, e.g., through the installation of a wall box, and overnight home charging can be ensured at dedicated off-street parking spaces (McKinney et al., 2023; Scorrano et al., 2020). The number of cars per household might also affect BEV purchase intention, although the direction of the effect is unclear (Wicki, Brückmann, Quoss, et al., 2022). Whereas some studies have found that the number of a cars in a household increases BEV acceptance (Jensen et al., 2013; Lee et al., 2019; Priessner et al., 2018), others have reported opposite effects (Hidrue et al., 2011; Nazari et al., 2018). Households with more cars appear to be able to rely on other cars to serve as a backup in terms of BEV range, thus reducing range anxiety (Jakobsson et al., 2016; Jensen et al., 2013; Karlsson, 2017). However, the evidence appears to be highly context -dependent and country-dependent, and the direction of the effect cannot be conclusively determined (Wicki, Brückmann, Quoss, et al., 2022).

Personal determinants influencing BEV uptake

In addition to product attributes and contextual determinants, research has focused on the personal consumer determinants influencing BEV uptake. The most frequently identified factors are presented below.

Several studies focusing on early adopters have shown that this group usually comprises middle-aged men, with high education and high income (Brückmann, 2022a; Hidrue et al., 2011; Sovacool et al., 2018; Trommer et al., 2015). The effect of gender on BEV uptake has not been fully examined, although gender differences play roles in mobility behaviour (Sovacool et al., 2018; Wicki, Brückmann, Quoss, et al., 2022). Consumers with higher levels of education have greater interest in BEVs (Carley et al., 2013; Sovacool et al., 2018; Wicki, Brückmann, Quoss, et al., 2022). Similar findings have been observed for income, wherein higher income is associated with greater interest in BEVs (Trommer et al., 2015; Wicki, Brückmann, Quoss, et al., 2022). In general, the influence of socio-demographic determinants on BEV uptake has been mixed (Wicki, Brückmann, Quoss, et al., 2022). Consumers' general environmental attitudes influence their car purchase decisions, and consumers with higher environmental awareness have been shown to have greater BEV acceptance (Carley et al., 2013; Jensen et al., 2013; Okada et al., 2019; Peloza et al., 2013). Similar relationships have been found regarding consumers' innovativeness, wherein higher the personal innovativeness is associated with greater acceptance of BEVs (Wicki, Brückmann, Quoss, et al., 2022).

BEV experience and familiarity can also increase BEV acceptance (Liu et al., 2020; Schmalfuß et al., 2017; Thøgersen & Ebsen, 2019; Wicki, Brückmann, Quoss, et al., 2022). Studies have shown that consumers with BEV experience have greater willingness to pay a premium for BEVs (Larson et al., 2014). In addition, BEV experience can reduce range anxiety and increase BEV range estimation (Franke & Krems, 2013; Rauh et al., 2015). Similar effects have been reported for BEV knowledge, wherein higher BEV knowledge is associated with greater BEV acceptance (Wang et al., 2018). Consumers with greater BEV knowledge rate the utility of BEVs higher (Rajper & Albrecht, 2020; Wang et al., 2018). In addition, greater BEV knowledge is associated with diminished misperception and information deficits (Axsen et al., 2017). However, BEV knowledge remains lacking among mainstream car buyers (Brückmann, 2022a; Long et al., 2019; Wang et al., 2018). More research in BEV knowledge transfer is necessary to increase BEV acceptance (Brückmann, 2022b). Greater BEV knowledge is crucial to increase BEV acceptance, because limited BEV acceptance is attributable to a lack of BEV knowledge (Long et al., 2019; Wang et al., 2018).

Consequently, consumers with more information about BEVs might be expected to be more likely to choose a BEV for their next car purchase. Furthermore, different levels of BEV knowledge should lead to different weighting of the aforementioned influencing factors. Some frequently described consumer barriers, such as range, charging infrastructure or charging time, should rationally be perceived as relatively less important, depending on the consumer's BEV knowledge. Therefore, our first study objective was to answer the following research question:

Research question 1: Does consumer knowledge of BEVs affect their perceived importance of factors influencing car purchase?

We next analysed the influence of BEV-related information on powertrain choice and evaluated the influencing factors. Research on BEV knowledge and its influence on powertrain choice is limited (Brückmann, 2022b; Haustein & Jensen, 2018). Almeida Neves et al. (2019) have argued that more information on the positive environmental footprint of BEVs is necessary to enable policymakers to increase the market share of BEVs. However, the authors have stated that policymakers should consider the different education levels of the target groups (Almeida Neves et al., 2019). Haustein et al. (2021) have found a knowledge gap regarding advances in BEVs among consumers, and have reported that more consumers must be made aware of advances in BEV technology and charging infrastructure. However, the researchers have demonstrated that providing positive BEV information has a smaller effect than providing negative BEV information (Haustein et al., 2021), in agreement with findings from other studies (e.g., Cherchi, 2017). In addition, Cheng et al. (2019) have shown that BEV information overload can lead to negative behavioural intentions regarding BEVs. The most frequently cited consumer barriers associated with BEV use are range, purchase price, charging infrastructure and charging time (Corradi et al., 2023; Wicki, Brückmann, Quoss, et al., 2022). However, because technological advances in recent years are likely to make some of these barriers less relevant (Forsythe et al., 2023; IEA, 2023b), consumers should be able to switch to BEVs more easily once they have received the relevant information. In addition, we expected that having greater information would shift the perceived weighting of the influencing factors from that in part 1 of this study. Therefore, the second objective of this article was to answer the following research question:

Research question 2: Do BEV-related information influence powertrain choice?

Finally, this article analysed the effects of the configuration of certain product attribute levels on powertrain choice. Prior research examining the tipping points at which consumers choose a BEV for certain product attributes has typically focused on the most commonly cited barriers of range, charging time and purchase price (e.g., Larson et al., 2014; Wicki, Brückmann, & Bernauer, 2022), as well as the importance of certain product attributes (Burs et al., 2020). However, those study findings are partly outdated and have limited generalisability because of advances in BEV technology, as well as potentially increased public knowledge and experience with BEVs. In contrast to prior studies, this study focused not on the exact calculation of product attribute levels but on a fictitious case in which consumers would be willing to change their powertrain choice. Therefore, in the last part of the study, the influences of free choice of certain product attributes commonly described as barriers on powertrain choice are analysed. The third objective of this study was therefore to answer the following research question:

Research question 3: How does vehicle configuration affect powertrain choice?

3 Method

An online survey study was conducted to answer the research questions. Participants were surveyed through the indirect questioning (IQ) method.

IQ is widely used in consumer research to reduce social desirability bias (Fisher, 1993; Rosenfeld et al., 2015). IQ can be used in surveying topics that might be sensitive, confidential or embarrassing for respondents (Fisher & Tellis, 1998; Hoffmann et al., 2017; Perri et al., 2023). To do so, IQ uses questions that do not directly address respondents and their views, but instead ask them to answer from another person's perspective, on the basis of an assumption that respondents project their own views in their responses.

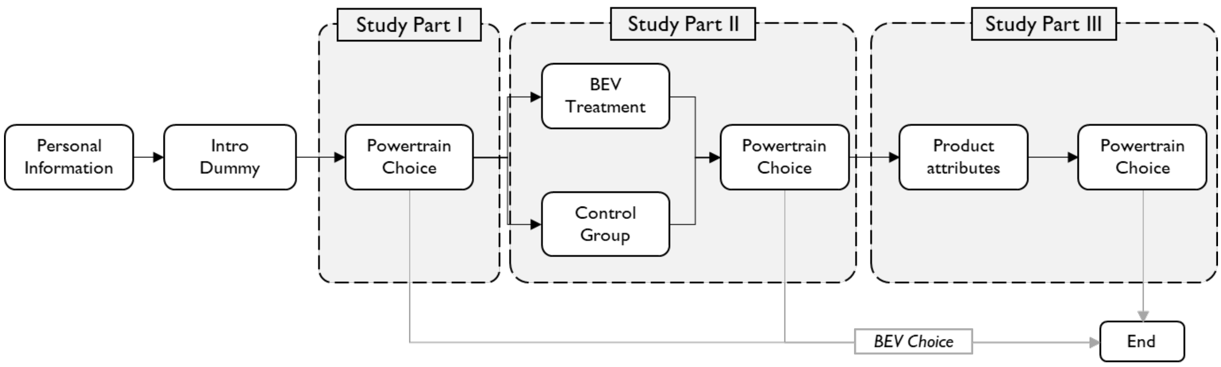
IQ has been successfully applied in the social sciences, with the caveat that IQ must be used with caution and should incorporate easily understood questions (Harel et al., 2022). For example, IQ has been used in the context of pre-election surveys (Waubert de Puiseau et al., 2017), compliance with hygiene rules during the COVID-19 pandemic (Kaufmann et al., 2022) and, in a mobility context, motives regarding mode choice among, e.g., car, public transport or walking (Hügler et al., 2023). Several studies have controlled for response behaviour in the context of direct and indirect questioning, and have indicated that IQ increases the proportion of socially undesirable responses (Hilbig et al., 2015; Kaufmann et al., 2022; Rosenfeld et al., 2015; Waubert de Puiseau et al., 2017).

In the context of this study, we assumed that the question of powertrain choice and the corresponding factors influencing that choice were issues that could be influenced by social desirability bias, such as that arising from media coverage stating the importance of switching to BEVs. In addition, a lack of knowledge regarding BEVs, such as the use and availability of charging infrastructure or existing product features, might also have led to embarrassment if participants were questioned directly. To avoid this bias and to enrich the methodological landscape of this research topic, we selected an IQ design.

IQ was used for all questions except those regarding socio-demographics and household characteristics. Overall, the questionnaire was divided into three parts, each addressing one research question presented in chapter 2. The study structure is shown in Figure 1.

Figure 1

Study structure



At the beginning of the study, participants first provided socio-demographic and socio-economic information about themselves and their households. After answering these questions, participants were allocated to predefined dummy profiles according to information provided about their gender, household income, region of residence and whether their household had a parking space for at least one car. A total of 16 dummy people were created. Avatar images were deliberately used instead of pictures to avoid excessive negative or positive emotions towards the dummy person (Salminen et al., 2021). After being provided with the avatar description[2], participants were asked to answer the following questionnaire from the perspective of the dummy person. Next, the dummy person's BEV knowledge, environmental friendliness and personal innovativeness were assessed with the exact wording shown in Appendix 1.

In part I, participants were asked what powertrain choice the dummy person's next car would have, among an ICEV, a BEV or an HEV. Participants were then asked to rate the importance of each factor influencing the dummy person's car purchase decision on a 7-point Likert scale, as shown in Table 1. All participants who chose and rated a BEV were considered to have completed the study, because the study was designed to focus on the drivers and barriers to BEV adoption from the perspective of participants choosing HEVs or ICEVs.

In part II, the remaining participants were randomly assigned to one of two groups and received information in the first step. The treatment group was first presented with information about cars in Germany, specifically, information on the average kilometres driven per day, daily parking time, number of refuelling stations, average refuelling time and average purchase price. Subsequently, information was provided about BEVs, specifically the current average range of BEVs, the number of (fast) charging points, charging times and the average purchase price. The detailed wording can be found in Appendix 2. To minimise

[2] For example: 'This is Maximilian. Maximilian works for a bank and lives in an urban area. He doesn't have his own parking space for his car and is looking for a flexible parking space. He is currently looking for a new car.'

the influence on BEV evaluation, the information was deliberately presented in a neutral style. An attempt was also made to minimise the amount of information presented to avoid information overload among participants. The control group was provided with geographical information about the world's five oceans. The information and exact wordings for both groups are shown in Appendix 2. In the second step, participants were asked about the dummy person's next powertrain choice, considering the information provided. All factors influencing the purchase decision from Table 2 were again rated on a 7-point Likert scale. As before, all participants who chose a BEV in this study part were considered to have completed the study.

In part III, the remaining participants were asked to specify product attributes of a fictional BEV. Participants were first asked to choose the tipping point at which the dummy person would select a BEV if the product attributes of range, charging time and purchase price were configured according to one of the attribute levels shown in Table 2.

Table 2
Product attributes of BEVs

No.	Product Attribute	Attribute Levels
1	Range	1) Up to 199 kilometres, 2) 200–299 kilometres, 3) 300–399 kilometres, 4) 400–499 kilometres, 5) 500–599 kilometres, 6) 600 kilometres or more
2	Charging time	1) 50–60 minutes, 2) 40–49 minutes, 3) 30–39 minutes, 4) 20–29 minutes, 5) 10–19 minutes, 6) 0–9 minutes
3	Purchase price	1) Up to 19,999 €, 2) 20,000–29,999 €, 3) 30,000–39,999 €, 4) 40,000–49,999 €, 5) 50,000–59,999 €, 6) 60,000–69,999 €, 7) 70,000 € or more

Note: The categories have been adjusted according to Deloitte (2024).

In the second step, participants were again asked about the dummy people's powertrain choices. Participants who chose a BEV were considered to have completed the study. The remaining participants were asked to specify further drivers and barriers in a free text field and were then considered to have completed the study.

4 Data

The data were collected via an online survey by the panel provider Norstat. Before the actual survey in February 2024, a pre-test was conducted with 102 participants using the Norstat panel. Participants were able to provide feedback on the study in a free response field. The questionnaire was then partly adapted.

The final survey included 877 participants in Germany. The questionnaire was thus conducted in German. The data were collected with Unipark software in March and April 2024. The data were first cleaned. Only people who intended to buy a new car in the next 3 years and were 18 years or older were interviewed. After approximately 75% of the total sample was completed, the remaining participants were sampled to achieve an equal gender distribution. Participants were automatically removed via software if they answered incorrectly during a quality check in part II of the study, and subsequently did not appear in the sample. An attention check was performed for the information presented to the participants (for the target group, the number of petrol stations in Germany; for the control group, the number of oceans). In addition, a time check was performed, such that all respondents taking too little or too much time to complete the questionnaire were removed. The pre-test indicated a sufficient time period of 171–600 seconds for part I of the study, 288–1,000 seconds for part II of the study and 324–1,800 seconds for part III of the study. Consequently, all participants who took less or more than these times to respond were excluded, to ensure data quality. After data cleaning, we obtained a final sample of 746 participants. To create BEV knowledge groups, we calculated the median measured BEV knowledge of the entire sample. The lower half of the sample was assigned to the low BEV knowledge (LBK) group, whereas the upper half of the sample was assigned to the high BEV knowledge (HBK) group. All analyses were conducted in IBM SPSS 28.

Table 3

Composition of the samples per study part

	Study Part I		**Study Part II**		**Study Part III**	
n	n=746		n=582		n=541	
Group	***LBK (n=371)***	***HBK (n=375)***	***LBK (n=324)***	***HBK (n=258)***	***LBK (n=312)***	***HBK (n=229)***
Gender	54% female	39% female	52% female	40% female	52% female	41% female
Age	50.10	52.97	50.52	53.30	50.78	53.14
Place of residence	49% city area	55% city area	47% city area	48% city area	47% city area	48% city area
Cars per household[1]	1.65	1.74	1.66	1.80	1.66	1.81
Average mileage per car	15,984	14,030	16,313	14,860	16,418	15,107
Own parking spot	86% yes	89% yes	85% yes	88% yes	85% yes	88% yes
BEV experience	50% yes	64% yes	48% yes	64% yes	49% yes	63% yes
BEV knowledge	3.722 (.824)	5.592 (.588)	3.696 (.837)	5.531 (.541)	3.705 (.828)	5.526 (.546)
Environmental awareness	4.706 (1.099)	5.347 (1.103)	4.650 (1.075)	5.159 (1.110)	4.646 (1.078)	5.068 (1.108)
Personal innovativeness	4.247 (1.159)	4.783 (1.338)	4.241 (1.186)	4.777 (1.299)	4.258 (1.181)	4.845 (1.257)
Powertrain choice	ICEV 216 (58%) HEV 108 (29%) BEV 47 (13%)	ICEV 148 (40%) HEV 110 (29%) BEV 117 (31%)	ICEV 195 (60%) HEV 117 (36%) BEV 12 (4%)	ICEV 126 (49%) HEV 103 (40%) BEV 29 (11%)	ICEV 108 (35%) HEV 115 (37%) BEV 89 (28%)	ICEV 68 (30%) HEV 94 (41%) BEV 67 (29%)

Notes. The constructs of BEV knowledge (Cronbach's α=0.651), environmental awareness (α=0.852) and personal innovativeness (α=0.714) are a sum of various factors measured on a 7-point Likert scale; details can be found in Appendix 1. Values in parentheses are standard deviations.
[1]Cars per household is measured as no car, one car, two cars, or three or more cars.

Table 3 shows the demographic characteristics of the sample. Compared with the HBK group, the LBK group generally had more participants who were women, lived in rural areas and had higher average mileage per car. In addition, the LBK group has less BEV experience, lower environmental awareness and less personal innovativeness.

5 Results and Discussion

5.1 Results for Study Part I

Table 4 shows the comparison of factors influencing car purchase according to powertrain choice and BEV knowledge in part 1. In the LBK group, 58% of participants chose an ICEV (n=216), 29% chose an HEV (n=108), and 13% chose a BEV (n=47). In the HBK group, 40% of participants chose an ICEV (n=148), 29% chose an HEV (n=110), and 31% chose a BEV (n=117).

Table 4

Comparison of influencing factors according to powertrain choice and BEV knowledge

Influencing Factors	ICEV (LBK)	ICEV (HBK)	t-test	HEV (LBK)	HEV (HBK)	t-test	BEV (LBK)	BEV (HBK)	t-test
Charging and refuelling cost	5.29	5.60	2.24*	5.80	5.89	.67	5.53	5.84	1.51
Charging and refuelling infrastructure	5.47	6.01	3.92***	5.84	6.02	1.23	5.57	6.22	4.01***
Charging and refuelling time	5.19	5.59	2.40*	5.69	5.86	1.16	5.40	5.83	2.21*
Driving pleasure	5.06	5.40	2.34*	4.76	5.29	3.25**	4.89	5.35	1.94
Engine power	4.42	4.91	3.35***	4.17	4.79	3.88***	4.28	4.73	1.75
Environmental impact	4.16	4.36	1.42	4.97	5.43	3.18**	5.06	5.75	3.18**
Government subsidies	3.91	3.70	-1.19	5.18	5.11	-.35	5.57	5.67	.42
Maintenance and repair cost	5.47	5.75	2.37*	5.80	5.84	.29	5.66	5.92	1.37
Possible ban on combustion vehicles	4.02	3.70	-1.61	4.56	4.50	-.31	4.34	4.79	1.76
Preferred brand vehicle category	4.55	4.81	1.76*	4.49	4.72	1.33	4.43	4.88	1.68
Production conditions	3.74	3.92	1.02	3.98	4.44	.24*	4.53	4.59	.21
Purchase price	5.70	5.99	2.50*	5.79	5.89	.70	5.85	5.85	.02
Range	5.78	5.99	1.56	5.86	5.96	.74	5.30	5.78	2.29*
Resale value	4.69	5.07	2.45*	4.86	5.25	2.17*	5.04	5.12	.30
Route planning for charging and refuelling	4.39	4.39	-.02	5.04	5.11	.41	4.87	5.56	2.92**
Vehicle category	4.79	5.28	3.78***	4.58	4.96	2.37*	4.49	5.14	2.83**

Note. Influencing factors were measured on a 7-point Likert scale, with 1 representing low importance and 7 representing high importance. Detailed t-test results can be found in Appendices 3, 4, and 5.Values in parentheses indicate standard deviation. *p < .05 **p < .01 ***p < .001

In a comparison among groups, the influencing factors ranked similarly, regardless of powertrain choice and differences in BEV knowledge. Participants rated the influencing factors of range, purchase price, charging and refuelling infrastructure, maintenance and repair cost, charging and refuelling cost, and charging and refuelling time as the most important factors influencing car purchase. The BEV LBK group rated range as less important and subsidies as more important than the other groups.

In the group comparison of ICEV choice, the LBK and HBK groups ranked the other influencing factors in similar orders of importance. Regarding ICEV choice, engine power, vehicle category and charging infrastructure were significantly more important for the HBK group than the LBK group. Because these three factors are closely related, the group with high BEV knowledge might have deliberately chosen not to purchase a BEV in favour of an ICEV. Higher engine power is associated with higher energy consumption for both ICEVs and BEVs. Larger BEVs enable larger battery capacities and therefore higher engine power and longer ranges (ADAC, 2024a). Consequently, only larger BEVs can currently compete with smaller ICEVs in terms of range. Finally, the greater importance of energy consumption and vehicle categories might have led to greater importance of the charging and refuelling infrastructure. A higher availability of the charging and refuelling infrastructure for ICEVs, particularly regarding the density of the charging network, might explain why these issues were rated as significantly more important by the ICEV HBK group. Second, the HBK group considered all factors to be more important than the LBK group, with the exception of government subsidies, a possible ban on combustion engine vehicles, and route planning for charging and refuelling, although the difference was not significant. In general, however, the mean of the different influencing factors was considerably higher for the HBK group than the LBK group. This finding might have indicated that, for the former group of consumers, a car is generally of higher importance, e.g., for respective individual purposes. Therefore, they may have rated the influencing factors as more important.

The factors influencing HEV choice were highly similar between the LBK and HBK groups. Government subsidies and a possible ban on combustion vehicles were considered more important for the LBK group than the HBK group, although the difference was not significant. The HBK group, in contrast, valued all other factors as more important than the LBK group, and significant differences between these groups were observed for engine power, environmental impact and driving pleasure. The results for engine power must be interpreted in a nuanced way for HEVs, because of the presence of an electric motor in addition to a combustion engine. The relatively higher engine power rating in the HBK group might have been because respondents were not yet fully convinced by the engine power of BEVs and therefore preferred to combine the compromises associated with both powertrains in a hybrid car. Depending on driving behaviour, HEVs also have a lower environmental impact than ICEVs (Orecchini et al., 2018), thus potentially explaining this aspect's higher rating in the HBK group than the LBK group. The significantly higher rating for driving pleasure in the HBK group than the LBK group also indicated that the combination of both powertrains was important to the HBK group, which did not want to entirely forgo an internal combustion engine. However, in general, the overall rating level of the different influencing factors was again considerably higher for the HBK group than the LBK group. This finding might again indicate that, for HBK consumers, the car generally seems to be of higher importance; therefore, this group weighed the influencing factors as more important.

The factors influencing BEV choice differed only slightly between the LBK and HBK groups. Overall, the HBK group rated all influencing factors as more important than the LBK group. Charging and refuelling infrastructure, route planning for charging, environmental impact and refuelling, and vehicle category were significantly more important for the HBK group. In considering the significant differences in influencing factors, two issues arose. First, the HBK group rated environmental impact as significantly more important than the LBK group. The positive environmental impact of BEVs has been demonstrated in numerous scientific studies (Hoekstra, 2019). Therefore, the HBK group probably had greater knowledge in that area and valued it accordingly. However, this finding might also indicate that the HBK group generally had greater environmental awareness than the LBK group, and was therefore more concerned about environmental issues and considered the corresponding impacts to be more important. Second, the influencing factors of charging and refuelling infrastructure and route planning for charging and refuelling are closely related. Again, the HBK group had greater experience with BEVs than the LBK group (as shown in Table 3) and was therefore more likely to know that the effort for route planning for charging and refuelling can be higher compared to known usage patterns with an ICEV, because the density of charging and refuelling infrastructure for BEVs remains lower. The influencing factor of vehicle category might also have indicated that the HBK group was more aware than the LBK group that the availability of BEV models, as compared with ICEV models, remains limited in terms of vehicle categories, restricting BEVs to certain ranges.

Our findings regarding research question 1 indicated that participants with greater BEV knowledge rated the importance of influencing factors higher when buying a car, independently of powertrain choice. Moreover, the most important factors appeared similar for all powertrain choices: most participants weighted range, purchase price, charging and refuelling infrastructure, maintenance and repair cost, charging and refuelling cost, and charging and refuelling time as the most important influencing factors when buying a car.

5.2 Results for Study Part II

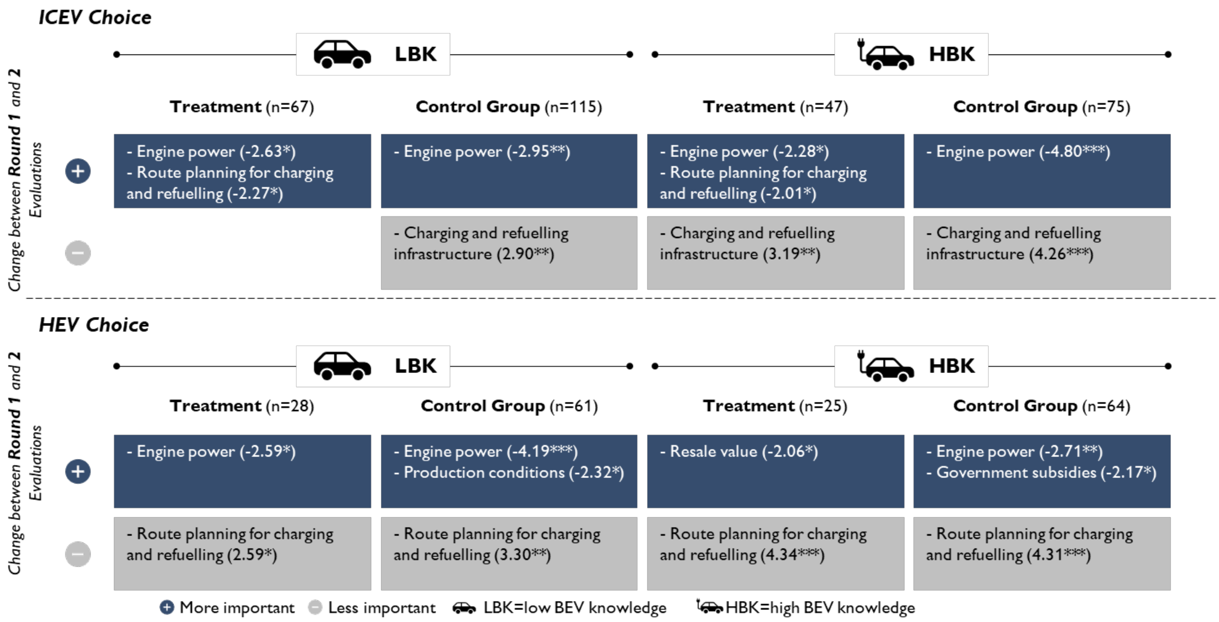
The following section presents and discusses the results for research question 2. Our aim was to demonstrate the influence of BEV information on powertrain choice. Part 2 of the study included only participants who did not choose a BEV in part 1, and instead chose an ICEV or HEV (n=582). The detailed BEV information provided to the treatment and control groups is shown in

Appendix 2. In the LBK group, 60% of participants chose an ICEV (n=195), 36% chose an HEV (n=117), and 4% chose a BEV (n=12). In the HBK group, 49% of participants chose an ICEV (n=126), 40% chose an HEV (n=103), and 11% chose a BEV (n=29). A total of 41 participants switched to a BEV in part 2. Of those, 16 had previously received the BEV-related information, and the other 25 had switched from the control group to the BEV group. In summary, the provision of BEV-related information in study part 2 did not appear to affect the participants' powertrain choice, because the number of participants (n=41) might have been too small to detect significant differences between groups.

Figure 2 summarises the statistically significant differences in evaluation of influencing factors by the ICEV and HEV participants between round I and round II for the HBK and LBK groups. All detailed t-test results can be found in Appendices 6, 7, 8 and 9.

Figure 2

Influencing factors for first and second vehicle assessment in the treatment and control groups



Note: Values in parentheses indicate t-test values. Detailed t-test results can be found in Appendices 6, 7, 8 and 9. *p < .05 **p < .01 ***p < .001.

Consumers in both the treatment and control groups, regardless of the corresponding powertrain choice, rated certain factors as relatively more or less important in a second evaluation. Almost all groups rated engine power as more important in the second round. For ICEV choice, both treatment groups rated route planning for charging and refuelling as more important. In contrast, charging and refuelling infrastructure became less important in almost all ICEV groups. For HEV choice, the treatment group HBK rated resale value as more important, and the control group HBK rated government subsidies as more important, whereas the HEV control group LBK rated production conditions as more important. All HEV groups rated route planning for charging and refuelling as less important.

The finding that ICEV groups rated influencing factors highly similarly indicated that the provision of BEV-related information had little effect on the participants' assessment of influencing factors. In contrast, engine power appeared to be relatively more important to participants, in general. The availability of the refuelling and charging infrastructure for ICEVs.is higher compared BEVs. Therefore, it remains unclear, why the assessment of route planning for charging and refuelling increased for the treatment group, and the assessment of refuelling and charging infrastructure decreased in parallel. Since engine power is very strongly associated with ICEVs, particularly in comparison to BEVs, many consumers might not be able to estimate the engine power of a BEV, as they could be biased by reference points resulting from ICEV use.

Because the HEV groups rated influencing factors very similarly, the provided BEV-related information appeared to have only a small effect on the participants' weighting of the influencing factors. The HEV treatment group's higher weighting of resale value relates to a topic widely discussed in the media regarding BEVs (Hartmann, 2024). The higher weighting for the resale value of HEVs might have indicated that participants chose to buy an HEV rather than a BEV. The information provided during the treatment regarding the availability of charging and refuelling stations might have influenced the treatment groups' weighting of route planning for charging and refuelling as less important. However, the HBK control group also rated this factor as less important, for which no direct interpretation can be found. The higher importance of the influence factor government subsidies (ADAC, 2024c) and the production conditions of BEVs are topics widely discussed in media. This might create prejudices from consumers against BEVs (Haas & Globig, 2023; Sonnenholzner, 2024).

For research question 2, BEV-related information did not appear to influence the choice of powertrain, as reflected by the low number of participants changing their powertrain choice after receiving BEV-related information. In addition, participants in both the target and control groups rated certain factors as more important in a second evaluation. However, the results should be interpreted with caution.

5.3 Results for Study Part III

The following section presents the results of part 3 of the study. First, the BEV product attributes of the participants who chose a BEV in round 3 are presented. Second, selected quotations from participants who rejected BEVs are presented and discussed. Part 3 of the study included only participants who did not choose a BEV in part 2, and instead chose an ICEV or HEV (n=541). After configuration of the BEV product attribute levels in part 3, in the LBK group, 35% of the participants chose an ICEV (n=108), 37% chose an HEV (n=115), and 28% chose a BEV (n=89). In the HBK group, 30% of the participants chose an ICEV (n=68), 41% chose an HEV (n=94), and 29% chose a BEV (n=67).

5.3.1 Product Attribute Levels

Figure 3

BEV product attributes in round III

	LBK Treatment (n=31)	LBK Control Group (n=58)	HBK Treatment (n=24)	HBK Control Group (n=43)
Range	400 – 499 kilometres M=4.81	500 – 599 kilometres M=5.07	400 – 499 kilometres M=4.92	400 – 499 kilometres M=4.74
Charging time	20 – 29 minutes M=4.48	20 – 29 minutes M=4.09	20 – 29 minutes M=4.62	30 – 39 minutes M=3.93
Purchase Price	20,000 – 29,999 € M=2.68	20,000 – 29,999 € M=2.45	30,000 – 39,999 € M=3.25	20,000 – 29,999 € M=2.74

LBK=low BEV knowledge HBK=high BEV knowledge

Note: M indicates mean values. Only respondents who chose a BEV in study part III after selecting individual product attributes were considered.

Figure 3 illustrates the selected BEV product attribute levels for range, charging time and purchase price. The results for the treatment and control groups are sorted by HBK and LBK.

Participants except those in the LBK control group chose a range of 400–499 kilometres, whereas those in the LBK control group chose a range of 500–599 kilometres. The average range of current BEVs described in the treatment was 350–450 kilometres; therefore, the findings can be interpreted in two ways. First, the treatment group might have been anchored by this range. However, this possibility might be contradicted by the HBK control group also having chosen this range. In contrast, the LBK control group chose a higher range, thus potentially indicating that those participants tended to choose a high range without context, because of the well-known 'range anxiety' phenomenon and a lack of information. Second, the findings might indicate that the current ranges of many BEVs are already sufficient. Therefore the additional product attributes of BEVs might have been the reason why many consumers still decided against a BEV.

Participants except those in the HBK control group chose a charging time of 20–29 minutes, whereas those in the HBK control group chose a charging time of 30–39 minutes. Notably, both treatment groups again chose a charging time closely associated with the 20 minutes indicated during the treatment. Therefore, whether the group might have chosen a BEV with that charging time or whether they remained anchored to the values during the treatment remains unclear. Because the HBK control group indicated a charging time of 30–39 minutes, additional product attributes of BEVs might have been the reason why many consumers still decided against a BEV, similarly to the findings regarding range.

The BEV purchase price chosen by three groups was €20,000–29,000; the HBK treatment group chose a price of €30,000–39,000. These findings might have several explanations. First, the HBK treatment group rated the purchase price of a BEV as relatively less important; this group might have been more aware of the lower TCO. Second, the findings might indicate that the HBK treatment group was generally more enthusiastic about cars and consequently had greater willingness to pay for a new car. Third, these results might suggest that the HBK treatment group remained anchored to the average purchase price during the treatment. Finally, the price range of €20,000–29,000 might indicate a need for less expensive BEVs, because the BEV product offerings in this segment are, today, relatively low. Consequently, BEVs might have remained a niche product, because the technology is available primarily in more expensive vehicles and brands, thus excluding lower-income consumer groups.

5.3.2 BEV Barriers

Among participants in part 3, 71% (n=385) chose not to purchase a BEV, despite the configuration of the individual product attribute levels for range, charging time and purchase price. Open-ended questions allowed those participants to explain their reasons for not choosing a BEV in favour of an ICEV or HEV. Frequently described topics and the resulting patterns are discussed below.

One of the most cited barriers to BEVs related to charging infrastructure:

> ‘No home charging infrastructure. Few charging points in the countryside’. (Male, 58 years, LBK, HEV choice)

Various studies have shown that the ability to charge BEVs at home provides consumers with greater flexibility (Liao et al., 2023; Scorrano et al., 2020). Moreover, 50–80% of charging processes occur at homes (Hardman et al., 2018). However, not all BEV consumers will have stable access to home charging in the future and therefore will depend on public charging infrastructure (Liao et al., 2023). The public charging infrastructure has substantially expanded in recent years, in terms of both the number of charging points and the distance to the nearest charging point (Bundesnetzagentur, 2024). However, the density of charging points is less than that of conventional petrol stations. Notably, the charging infrastructure in rural areas is less well developed than that in urban areas; consequently, use of BEVs, particularly regarding charging, is less flexible than use of HEVs and ICEVs.

Another issue described by participants, and currently receiving substantial media attention, is the resale value of BEVs:

> ‘The resale market has completely collapsed – yesterday on TV: the biggest used car dealer in town is no longer accepting electric cars’. (Male, 63 years, LBK, ICEV choice)

Many first-generation BEVs are now entering the used car market. However, because of insufficient demand for BEVs, the prices for both new and used BEVs have fallen. Low resale value is currently distorting the TCO of BEVs. At present, forecasts of future resale values are subject to volatility, thereby creating economic uncertainty for potential consumers. In addition, many consumers are uncertain about future developments and possible advances in BEVs, particularly regarding battery technology, as reflected by the following quotation:

> ‘Electric vehicles are not yet fully developed! You should wait about 5 years before buying one! There is a company car at work that is more at the garage than at the company!’ (Male, 64 years, LBK ICEV choice)

Because many consumers expect future technological developments for BEVs, such as longer ranges, they are reluctant to use BEVs and are instead waiting for further developments, in line with findings from other studies (Pradeep et al., 2021).

The following quotation also illustrates how safety concerns can lead to a general rejection of BEVs:

> ‘Environmentally damaging use of resources during production, possible battery fire, power failure or rationing’. (Male, 68, LBK, ICEV choice)

Safety concerns remained a frequently cited barrier for consumers regarding BEVs. The risk of fire and the difficulty of extinguishing a fire are sometimes discussed in the media, thus potentially leading consumers to choose familiar powertrain technologies. In addition, respondents cited general environmental concerns as a reason for rejecting BEVs, as supported by the following quotation:

> ‘Production process of the battery, the environmental impact is currently only transferred abroad. Disposal of used batteries. Can it be returned to the raw materials cycle? […]’ (Male, 56 years, HBK, HEV choice)

Concerns regarding the environmental benefits of BEVs persist among consumers. One such concern is the extraction of raw materials for BEVs, particularly lithium and cobalt. Mining these raw materials causes a degree of environmental damage and has repeatedly been reported to involve conditions violating labour rights. In addition, many consumers criticise the deficiencies in solutions for battery disposal or recycling. Because some raw materials are mined and recycled abroad, many consumers assume that emissions are simply transferred, and BEVs have no environmental benefit. However, this assumption has been disproven by research (Hoekstra, 2019).

Other barriers to BEVs might be more emotional than rational, as illustrated by the following quotations:

> ‘ […] Car is emotionless, no confidence in this propulsion technology’ (Male, 21 years, HBK, HEV choice)

> ‘Driving pleasure and engine noise’ (Male, 26 years, LBK, ICEV choice)

Our findings illustrate the emotional attachment that consumers may have towards products, particularly cars. For many consumers, buying a car is not a solely rational purchase decision, where purely financial, technological or ecological decisions play key roles (Sheller, 2004). In contrast, a purchase might be required to attain certain feelings and express a certain status in society (Gatersleben, 2011). Moreover, the lack of trust in drive technology appears to be a general psychological barrier rather than a rational one, as illustrated by the lack of driving pleasure and engine noise indicated by the respondents. In rational terms, BEVs are superior in both categories. BEVs can achieve significantly greater acceleration than ICEVs. In addition, less noise pollution from BEVs, particularly in urban areas, can benefit both society and car drivers. However, for consumers, driving a car not only must meet utilitarian needs but also must provide pleasure and satisfy hedonistic feelings.

For research question 3, we concluded that a fictitious configuration chosen by the participants for the product attributes of range, charging time and purchase price influenced powertrain choice: 28% of participants who chose an ICEV or HEV switched to a BEV after configuration. The product attribute levels also suggested that greater BEV knowledge and BEV-related information might lead to different expectations regarding BEV product attribute levels. In contrast, the responses to the open-ended questions indicated that consumers continue to reject BEVs for emotional and habitual reasons rather than rational reasons, as reflected by 72% of respondents choosing an HEV or ICEV after configuration of the selected product attributes.

6 Conclusion

The results of this study may provide a basis for understanding implications, limitations, and future research opportunities.

Car manufacturers may use these results as further evidence to enable continual improvement of BEV technology to increase consumer acceptance of BEVs. In particular, the issue of BEV range appears to be so entrenched among consumers that continued comparison with ICEVs seems inevitable, and ICEVs appear to be the reference category. As one measure, car manufacturers could offer smaller and less expensive BEVs to achieve greater market penetration, attract new BEV consumers and increase interest in BEVs. An initial approach could be to offer more HEVs to provide consumers with the experience of electric motors in cars. Another option might be to offer a buy-back guarantee for certain parts of BEVs, such as the battery, thus decreasing consumers' fears of missing out on technological advances and low future resale values. The results might also provide a basis for car manufacturers to emphasise emotions and habits when developing and advertising transition to BEVs, given that purely rational reasons may play an inferior part in consumers' decisions to buy a car.

These findings might also be used by policy makers. The development of (fast) charging infrastructure remained among the most important barriers to consumer acceptance of BEVs and should therefore be continually enhanced. Because a lack of information and knowledge regarding BEVs appeared to remain a barrier, efforts should continue to provide BEV-related information through appropriate websites, education and government campaigns. Such efforts could further decrease prejudices against BEVs. In addition, consumers appeared to remain attached to ICEVs, whereas HEVs appeared to be as popular as BEVs. Therefore, focusing only on BEVs might not be effective in accelerating the mobility transition, as HEVs hold certain potentials for greener mobility.

This study has several limitations. First, because the results show correlation, general conclusions should be drawn with caution. Although certain trends were observed, the relationship between BEV knowledge or BEV-related information and emotions, for instance, might include additional aspects beyond those measured in this study. Second, the use of IQ appeared appropriate for this study. Nevertheless, we did not control for successful mitigation of social desirability bias. In addition, the Cronbach alpha values were not high for all measured constructs, thus resulting in the removal of some factors, and potentially indicating that a portion of participants might have had problems with the type of questionnaire. In addition, items such as name, occupation and avatar were not counterbalanced, and their effectiveness was not measured. Third, the sampling was not controlled to achieve a representative sample. The various contextual determinants should be considered in interpreting the results, particularly their extrapolation to other countries. Finally, the presentation of BEV-related information during treatment might be a study limitation. Many participants might have experienced information overload.

Overall, the results provide a basis for further research. Future research should further investigate the influence of BEV knowledge and BEV-related information on powertrain choice. That research should include which type of BEV-related information and knowledge has the strongest effects on powertrain choice, e.g., the influences of financial, technical, or environmental aspects. How information on BEVs can be presented in different sales channels to appeal to different customer groups could also be considered. In addition, our results suggested that consumers are influenced by emotions when buying cars. Future research could include experimental studies to investigate the potential causal effects of emotions associated with car purchase on powertrain choice, e.g., by integrating brand, past car experiences or lifestyle.

Appendices

Appendix 1

Construct and Items of the questionnaire

Construct	Construct and Items	Cronbach α
Environmental Awareness		0.852
Adapted from Peloza et al. (2013)	I value taking care of the environment.	
	~~I find it not important to make environmentally sustainable choices.~~	
	I place a high value on conserving our natural resources.	
	~~It is not important to consider our impact on the environment.~~	
Personal Innovativeness		0.714
Goldsmith and Hofacker (1991)	I am among the last in my circle of friends to use a new technology when it appears.	
	~~If I heard that new technology product was available in the store, I would be interested enough to purchase it.~~	
	Compared to my friends, I own only a few technology products.	
BEV Knowledge		0.651
Burs et al. (2020); (adapted from Smith & Park, 1992)	~~I am not familiar with electric vehicles.~~	
	I am aware of some electric car models that are on the market.	
	I have a good idea about the charging options for electric vehicles in my city and country.	

Note. Within the survey, items were translated into German. Some items were inverted as an additional attention check. However, a Cronbach's $\alpha > 0.6$ for the overall construct was only achieved by deleting certain items as shown in the table.

Appendix 2

Information for the two different groups in Part II

Group 1	**Group 2 (Control Group)**
Information on cars in Germany: - The average distance travelled per day is about 37 km (MotoIntegrator, 2022; Nobis & Kuhnimhof, 2018). - On average, a car is driven for about 1 hour per day, i.e. it is parked for an average of 23 hours per day (MotoIntegrator, 2022; Nobis & Kuhnimhof, 2018). - In Germany there are about 14,500 petrol stations for cars with internal combustion engines (petrol or diesel) (ADAC, 2021; EHI, 2024). - Refuelling takes about 10 minutes (Hense, 2019). - The average purchase price of a new car with a combustion engine (petrol or diesel) is currently around €43,000 (DAT, 2024). **Electric car (100% battery electric drive):** - The average driving range of an electric car is currently between 350 and 450 kilometres (TCS, 2024b). - There are currently around 56,000 public charging points in Germany (with around 85,000 charging points, of which 21,000 are fast chargers)(Roth, 2024). - There are a total of 2,023 public fast charging stations (equivalent to a conventional petrol station) (Roth, 2024). - The charging time varies depending on the type of charger and is around 20 minutes for 80% of battery capacity with current fast chargers (ADAC, 2023). - The average purchase price of an electric car is currently around €52,700 (Tagesschau, 2023).	**There are five major oceans on Earth, each with a different size:** - Pacific Ocean (168,723,000 sq. km) - Atlantic Ocean (85,133,000 sq. km) - Indian Ocean (70,560,000 sq. km) - South Seas (21,960,000 sq. km) - Arctic Ocean (15,558,000 sq. km) (Abbany, 2016)

Note. Both groups were asked control questions after the information in order to maintain the quality of the sample. Group 1 was asked about the number of petrol stations in Germany and group 2 about the number of oceans in the world. People with incorrect answers were removed from the sample. The sources of information were not part of the online survey.

Appendix 3

Comparison of influencing factors by ICEV choice and BEV knowledge

Influencing Factors	**ICEV (LBK)**	**ICEV (HBK)**	**T**	**df**	**Significance (two-sided)**	**Cohen's d**
Engine Power	4.42 (1.30)	4.91 (1.48)	3.35	362	< .001	.36
Range	5.78 (1.25)	5.99 (1.36)	1.56	362	.120	.17
Charging and refuelling time	5.19 (1.64)	5.59 (1.53)	2.40	362	.017	.26
Vehicle category	4.79 (1.25)	5.28 (1.21)	3.78	362	< .001	.40
Preferred brand vehicle category	4.55 (1.35)	4.81 (1.48)	1.76	362	.079	.19
Charging and refuelling infrastructure*	5.47 (1.36)	6.01 (1.25)	3.92	333.296	< .001	.41
Environmental impact	4.16 (1.34)	4.36 (1.40)	1.42	362	.155	.15
Government subsidies	3.91 (1.67)	3.70 (1.74)	-1.19	362	.234	-.13
Purchase price*	5.70 (1.16)	5.99 (1.02)	2.50	339.757	.013	.26
Charging and refuelling costs	5.29 (1.30)	5.60 (1.30)	2.24	362	.026	.24
Resale value	4.69 (1.40)	5.07 (1.57)	2.45	362	.015	.26
Maintenance and repair costs	5.47 (1.10)	5.75 (1.11)	2.37	362	.018	.25
Possible ban on ICEVs*	4.02 (1.75)	3.70 (1.95)	-1.61	293.083	.110	-.18
Production conditions	3.74 (1.58)	3.92 (1.70)	1.02	362	.308	.11
Route planning for charging and refuelling*	4.39 (1.66)	4.39 (1.89)	-0.20	287.783	.984	-.00
Driving pleasure	5.06 (1.36)	5.40 (1.40)	2.34	362	.020	.25

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance. Values in brackets indicate standard deviation. *due to unbalanced variances, the Welch test was conducted.

Appendix 4

Comparison of influencing factors by HEV choice and BEV knowledge

Influencing Factors	HEV (LBK)	HEV (HBK)	T	df	Significance (two-sided)	Cohen's d
Engine Power	4.17 (1.14)	4.79 (1.24)	3.88	216	< .001	.53
Range	5.86 (1.04)	5.96 (1.02)	.74	216	.463	.10
Charging and refuelling time	5.69 (1.11)	5.86 (1.05)	1.16	216	.247	.16
Vehicle category	4.58 (1.19)	4.96 (1.17)	2.37	216	.018	.32
Preferred brand vehicle category	4.49 (1.19)	4.72 (1.33)	1.33	216	.184	.18
Charging and refuelling infrastructure*	5.84 (1.15)	6.02 (.95)	1.23	206.741	.221	.17
Environmental impact	4.97 (1.06)	5.43 (1.05)	3.18	216	.002	.43
Government subsidies	5.18 (1.42)	5.11 (1.43)	-.35	216	.729	-.05
Purchase price	5.79 (1.02)	5.89 (1.17)	.70	216	.486	.10
Charging and refuelling costs	5.80 (1.03)	5.89 (1.05)	.67	216	.503	.09
Resale value	4.86 (1.36)	5.25 (1.26)	2.17	216	.031	.29
Maintenance and repair costs	5.80 (1.05)	5.84 (.99)	.29	216	.772	.04
Possible ban on ICEVs*	4.56 (1.41)	4.50 (1.66)	-.31	211.501	.756	-.04
Production conditions	3.98 (1.38)	4.44 (1.46)	.24	216	.019	.32
Route planning for charging and refuelling	5.04 (1.30)	5.11 (1.27)	.41	216	.679	.06
Driving pleasure	4.76 (1.29)	5.29 (1.12)	3.25	216	.001	.44

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance. Values in brackets indicate standard deviation. *due to unbalanced variances, the Welch test was conducted.

Appendix 5

Comparison of influencing factors by BEV choice and BEV knowledge

Influencing Factors	BEV (LBK)	BEV (HBK)	T	df	Significance (two-sided)	Cohen's d
Engine Power	4.28 (1.31)	4.73 (1.56)	1.75	162	.083	.30
Range	5.30 (1.20)	5.78 (1.22)	2.29	162	.023	.40
Charging and refuelling time	5.40 (1.14)	5.83 (1.10)	2.21	162	.028	.38
Vehicle category	4.49 (1.18)	5.14 (1.38)	2.83	162	.005	.49
Preferred brand vehicle category	4.43 (1.30)	4.88 (1.67)	1.68	162	.096	.29
Charging and refuelling infrastructure	5.57 (1.06)	6.22 (.88)	4.01	162	< .001	.69
Environmental impact	5.06 (1.26)	5.75 (1.25)	3.18	162	.002	.55
Government subsidies	5.57 (1.33)	5.67 (1.26)	.42	162	.677	.07
Purchase price	5.85 (1.20)	5.85 (1.13)	.02	162	.985	.00
Charging and refuelling costs	5.53 (1.30)	5.84 (1.11)	1.51	162	.132	.26
Resale value	5.04 (1.44)	5.12 (1.48)	.30	162	.762	.05
Maintenance and repair costs	5.66 (1.19)	5.92 (1.08)	1.37	162	.172	.24
Possible ban on ICEVs*	4.34 (1.36)	4.79 (1.72)	1.76	107.053	.082	.27
Production conditions	4.53 (1.46)	4.59 (1.68)	.21	162	.836	.04
Route planning for charging and refuelling	4.87 (1.54)	5.56 (1.28)	2.92	162	.004	.50
Driving pleasure	4.89 (1.29)	5.35 (1.39)	1.94	162	.054	.34

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance. Values in brackets indicate standard deviation. *due to unbalanced variances, the Welch test was conducted.

Appendix 6

Comparison of influencing factors by BEV choice and BEV knowledge

	Treatment (n=47)						Control Group(n=75)					
Influencing Factors	**ICEV 1. (HBK)**	**ICEV 2. (HBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**	**ICEV 1. (HBK)**	**ICEV 2. (HBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**
Engine Power	5.09	5.40	-2.28	46	.027	-.33	4.88	5.37	-4.80	74	< .001	-.55
Range	5.98	6.06	-.38	46	.699	-.06	6.03	6.00	.21	74	.831	.03
Charging and refuelling time	5.51	5.51	.00	46	1.000	.00	5.68	5.44	1.72	74	.089	.20
Vehicle category	5.40	5.32	.56	46	.577	.08	5.27	5.12	1.56	74	.124	.18
Preferred brand vehicle category	5.00	4.85	1.02	46	.312	.15	4.65	4.79	-1.15	74	.254	-.13
Charging and refuelling infrastructure	6.00	5.66	3.19	46	.003	.47	6.05	5.45	4.26	74	< .001	.49
Environmental impact	3.98	3.96	.20	46	.844	.03	4.37	4.31	.53	74	.595	.06
Government subsidies	2.94	3.13	-1.20	46	.237	-.18	3.83	3.68	1.21	74	.230	.14
Purchase price	5.79	5.98	-1.50	46	.141	-.22	6.08	6.00	.88	74	.380	.10
Charging and refuelling costs	5.38	5.40	-.15	46	.881	-.02	5.68	5.72	-.30	74	.765	-.04
Resale value	4.81	4.74	.57	46	.569	.084	5.11	5.07	.40	74	.694	.05
Maintenance and repair costs	5.66	5.32	1.83	46	.073	.27	5.71	5.67	.48	74	.634	.06
Possible ban on ICEVs	3.28	3.47	-.99	46	.329	-.14	3.61	3.57	.32	74	.747	.04
Production conditions	3.64	3.62	.09	46	.930	.01	3.95	4.05	-1.16	74	.251	-.13
Route planning for charging and refuelling	3.87	4.28	-2.01	46	.050	-.29	4.45	4.68	-1.33	74	.188	-.15
Driving pleasure	5.38	5.45	-.65	46	.519	-.10	5.51	5.41	1.19	74	.239	.14

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance.

Appendix 7

Comparison of influencing factors by BEV choice and BEV knowledge

	Treatment (n=67)						Control Group (n=115)					
Influencing Factors	**ICEV 1. (LBK)**	**ICEV 2. (LBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**	**ICEV 1. (LBK)**	**ICEV 2. (LBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**
Engine Power	4.51	4.79	-2.63	66	.011	-.32	4.46	4.84	-2.95	114	.004	-.28
Range	5.60	5.55	.38	66	.708	.05	5.99	5.82	1.57	114	.119	.15
Charging and refuelling time	4.97	5.13	-1.26	66	.212	-.15	5.35	5.30	.45	114	.653	.04
Vehicle category	4.85	4.75	1.07	66	.289	.13	4.84	4.82	.24	114	.811	.02
Preferred brand vehicle category	4.54	4.52	.16	66	.871	.02	4.59	4.61	-.16	114	.871	-.02
Charging and refuelling infrastructure	5.31	5.30	.12	66	.902	.02	5.57	5.27	2.90	114	.004	.27
Environmental impact	4.21	4.10	.98	66	.331	.12	4.06	4.03	.30	114	.767	.03
Government subsidies	3.93	3.78	1.52	66	.133	.19	3.88	3.77	1.05	114	.298	.10
Purchase price	5.81	5.78	.29	66	.771	.04	5.67	5.75	-.83	114	.408	-.08
Charging and refuelling costs	5.30	5.22	.71	66	.479	.09	5.23	5.30	-.98	114	.331	-.09
Resale value	4.63	4.69	-.53	66	.597	-.07	4.69	4.63	.70	114	.488	.07
Maintenance and repair costs	5.30	5.37	-.76	66	.450	-.09	5.52	5.51	.12	114	.905	.01
Possible ban on ICEVs	3.97	3.81	1.18	66	.241	.15	3.83	3.70	1.14	114	.256	.11
Production conditions	3.78	3.87	-.66	66	.512	-.08	3.63	3.76	-1.33	114	.187	-.12
Route planning for charging and refuelling	4.37	4.70	-2.27	66	.027	-.28	4.35	4.42	-.81	114	.421	-.08
Driving pleasure	4.97	4.94	.29	66	.771	.04	5.09	5.10	-.20	114	.846	-.02

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance.

Appendix 8

Comparison of influencing factors by BEV choice and BEV knowledge

	Treatment (n=25)						Control Group (n=64)					
Influencing Factors	**HEV 1. (HBK)**	**HEV 2. (HBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**	**HEV 1. (HBK)**	**HEV 2. (HBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**
Engine Power	4.68	5.04	-1.81	24	.083	-.36	4.63	4.94	-2.71	63	.009	-.34
Range	6.12	6.20	-.81	24	.425	-.16	5.86	5.89	-.31	63	.755	-.04
Charging and refuelling time	6.08	6.00	.53	24	.603	.11	5.73	5.72	.13	63	.896	.02
Vehicle category	5.12	5.08	.25	24	.802	.05	4.94	4.98	-.40	63	.694	-.05
Preferred brand vehicle category	5.04	5.08	-.37	24	.714	-.07	4.72	4.75	-.25	63	.802	-.03
Charging and refuelling infrastructure	6.28	6.20	.70	24	.491	.14	5.95	5.81	1.09	63	.282	.14
Environmental impact	5.48	5.24	1.81	24	.083	.36	5.38	5.38	.000	63	1.000	.00
Government subsidies	5.20	5.32	-1.14	24	.265	-.23	4.94	5.20	-2.17	63	.034	-.27
Purchase price	6.08	6.12	-.20	24	.840	-.04	5.81	5.75	.45	63	.654	.06
Charging and refuelling costs	5.96	6.04	-.63	24	.538	-.13	5.81	5.73	.71	63	.479	.09
Resale value	5.28	5.56	-2.06	24	.050	-.41	5.08	5.13	-.55	63	.581	-.07
Maintenance and repair costs	5.80	6.00	-1.10	24	.284	-.22	5.80	5.67	1.16	63	.251	.15
Possible ban on ICEVs	4.72	5.00	-.96	24	.347	-.19	4.33	4.42	-1.06	63	.292	-.13
Production conditions	4.16	4.52	-1.40	24	.175	-.28	4.42	4.59	-1.37	63	.174	-.17
Route planning for charging and refuelling	6.28	5.40	4.34	24	<.001	.87	5.95	5.25	4.31	63	<.001	.54
Driving pleasure	5.44	5.48	-.44	24	.664	-.09	4.13	5.09	.34	63	.735	.04

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance.

Appendix 9

Comparison of influencing factors by BEV choice and BEV knowledge

	Treatment (n=28)						Control Group (n=61)					
Influencing Factors	**HEV 1. (LBK)**	**HEV 2. (LBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**	**HEV 1. (LBK)**	**HEV 2. (LBK)**	**t-test**	**df**	**Significance (two-sided)**	**Cohen's d**
Engine Power	4.36	4.93	-2.59	27	.015	-.49	4.11	4.59	-4.19	60	<.001	-.54
Range	6.00	6.11	-.68	27	.501	-.13	5.84	5.89	-.47	60	.643	-.06
Charging and refuelling time	5.93	5.79	.64	27	.526	.12	5.62	5.79	-1.80	60	.077	-.23
Vehicle category	4.86	4.86	.00	27	1.000	0.00	4.51	4.54	-.25	60	.805	-.03
Preferred brand vehicle category	4.68	4.43	1.10	27	.282	.21	4.56	4.48	.90	60	.374	.12
Charging and refuelling infrastructure	6.00	5.68	1.27	27	.213	.24	5.87	5.8	.60	60	.551	.08
Environmental impact	5.07	4.93	.89	27	.381	.17	5.00	5.13	-1.38	60	.172	-.18
Government subsidies	5.36	5.14	1.14	27	.264	.22	5.20	5.18	.23	60	.821	.03
Purchase price	5.82	5.96	-.89	27	.381	-.17	5.77	5.72	.46	60	.651	.06
Charging and refuelling costs	5.68	5.93	-1.57	27	.129	-.30	5.85	5.80	.69	60	.496	.09
Resale value	5.00	5.46	-1.75	27	.091	-.33	4.79	4.74	.62	60	.536	.08
Maintenance and repair costs	5.93	5.93	.00	27	1.000	.00	5.75	5.75	.00	60	1.000	.00
Possible ban on ICEVs	4.61	4.64	-.16	27	.876	-.03	4.66	4.61	.38	60	.704	.05
Production conditions	3.96	4.39	-2.12	27	.043	-.40	4.16	4.41	-2.32	60	.024	-.30
Route planning for charging and refuelling	6.00	5.25	2.59	27	.015	.49	5.87	5.38	3.30	60	.002	.42
Driving pleasure	4.79	5.00	-1.24	27	.227	-.23	4.80	4.87	-.68	60	.497	-.09

Note. Influencing factors were measured on a 7-likert scale with 1 being of low importance and 7 being of high importance.

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