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A Study on the Preference of Electric Vehicle Front Design Elements

Zhiyou Sun and Kyungjin Park *

Department of Industrial Design, Hanyang University, ERICA Campus, Ansan 15588, Republic of Korea; sun4888@hanyang.ac.kr
* Correspondence: pkj4321@hanyang.ac.kr

Abstract: In order to invigorate Korea's pure electric vehicle market, innovative changes are imperative in both technological advancements and exterior design aesthetics. The front fascia, being the nucleus of car design, profoundly influences not only brand perception but also consumer preferences and purchasing decisions. Hence, the significance of front-end design in pure electric vehicle engineering is becoming increasingly evident. This study aims to assess the front-end design of electric vehicles and delineate the design aesthetics favored by consumers. Focusing on the exterior design aspects of electric vehicles, the study participants were limited to adults aged 20 or above. Utilizing Maximum Difference Scaling, a questionnaire was formulated, and preferences for front-end elements (headlamps, bonnet, bumper, grille, and side mirrors) were scrutinized through cross-tabulation analysis. The findings revealed the bonnet as the most preferred element, with a preference towards simplistic designs observed across all elements, including the bumper, grille, and side mirrors. Headlamps ranked as the second most preferred element, with a tendency towards emotionally evocative designs. This study offers insights into consumer preferences regarding the front-end elements of electric vehicles and is poised to contribute to the revitalization of Korea's pure electric vehicle market by providing pertinent information to future electric vehicle manufacturers.

Keywords: pure (battery) electric vehicle; front design elements; MaxDiff

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1. Introduction

1.1. Research Background and Purpose

According to the German market research company Statista Research Department [1], global sales of electric and battery electric vehicles are anticipated to experience significant growth between 2020 and 2025. While hybrid vehicles remain popular due to their enhanced mileage and cost-effectiveness, the competitiveness of electric vehicles is projected to surge owing to ongoing advancements in battery storage technology. It is forecasted that by 2025, electric vehicles will capture approximately a quarter of the global market share, with pure electric vehicles constituting around 7.4% of total global car sales. Furthermore, projections suggest that the market share of electric vehicles will soar to approximately 80% by 2050. However, in Korea, electric vehicle sales are experiencing a downward trend, evidenced by the sale of fewer than 10,000 units in August 2023, marking a 5.7% decline in sales from January to August 2023 [2].

Presently, various research endeavors related to electric vehicles are underway in Korea, predominantly focusing on technology, performance, and autonomous driving. However, research on electric vehicle design remains inadequate, necessitating a differentiation strategy to stimulate consumer interest and drive purchases through innovative design. The front fascia, being the crux of car design, is deemed a pivotal component influencing not only brand perception, but also consumer attitudes and purchase decisions. Hence, this study aims to delve into consumer preferences regarding the front-end elements of electric vehicles and propose future design directions.

Furthermore, this study undertakes an analysis of the key factors prioritized by consumers, alongside investigating preferences for electric vehicle design styles. It elucidates the significance and priority of various factors pertinent to electric vehicles' characteristics, thereby facilitating the alignment of consumer needs with product offerings. By doing so, we aim to contribute to informed decision making and service provision. The structure of this study encompasses theoretical background, research methodology, findings and discussion, and conclusion sections. With the escalating prominence of electric vehicles, there arises a pressing need for intensified design research, and this paper endeavors to yield meaningful insights in this context.

1.2. Research Scope and Method

This study targets the exterior design of a pure electric vehicle with the fewest design restrictions. Existing internal combustion engine vehicles had many limitations in terms of design due to their complex drive systems. Nevertheless, automobile manufacturers have emphasized their brand image through automobile exterior design using elements such as grills and emblems. However, the current pure electric vehicle exterior design is unable to find an innovative design language despite technological advancements. Accordingly, this study analyzes the designs preferred by users for the front of pure electric vehicles and discusses future trends in electric vehicle front design [3].

To achieve this objective, the study initially identifies the prevailing design styles of pure electric vehicles through a review of the existing literature. Subsequently, the components of front-end design are categorized and examined. Expert interviews and focus group sessions are conducted to gather insights into the design preferences for each front-end element. Additionally, demographic information from 220 participants is analyzed using SPSS, and their preferred designs for each front-end element are evaluated.

Based on the findings, the study discusses the design styles favored by consumers for pure electric vehicles and elucidates the trends essential for future design development in this sector. By synthesizing user preferences and demographic data, this study contributes to shaping the future direction of pure electric vehicle design, fostering innovation and consumer satisfaction in the automotive industry.

2. Theoretical Background

2.1. Classification of Electric Vehicles

Conventional internal combustion engine vehicles use fuel to generate power. Vehicles that are powered by electrical energy are called electric vehicles. Currently, electric vehicles include pure (battery) electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs), fuel cell electric vehicles (FCEVs), and general hybrid vehicles (HEVs) [4], depending on the method of generating electrical energy [Figure 1].

1. Pure (battery) electric vehicle (BEV): A vehicle that does not use any fuel such as gasoline and runs solely on electricity. This is a vehicle that runs on an electric motor powered by a battery, and requires fewer parts compared to an internal combustion engine vehicle.
2. Plug-in hybrid electric vehicle (PHEV): A vehicle equipped with both gasoline and electric motors. It can be driven using electricity, and when the battery runs out, it switches to a regular internal combustion engine and drives.
3. Fuel cell electric vehicle (FCEV): Like a pure electric vehicle, it operates on electricity, but the power system is not a battery. Instead, it generates electricity by chemically combining hydrogen gas in the vehicle tank and oxygen in the air.
4. Hybrid electric vehicle (HEV): A vehicle that operates by combining an internal combustion engine and an electric motor. The electric motor is charged while driving, and the gasoline engine and electric motor operate by simultaneously rotating the transmission.

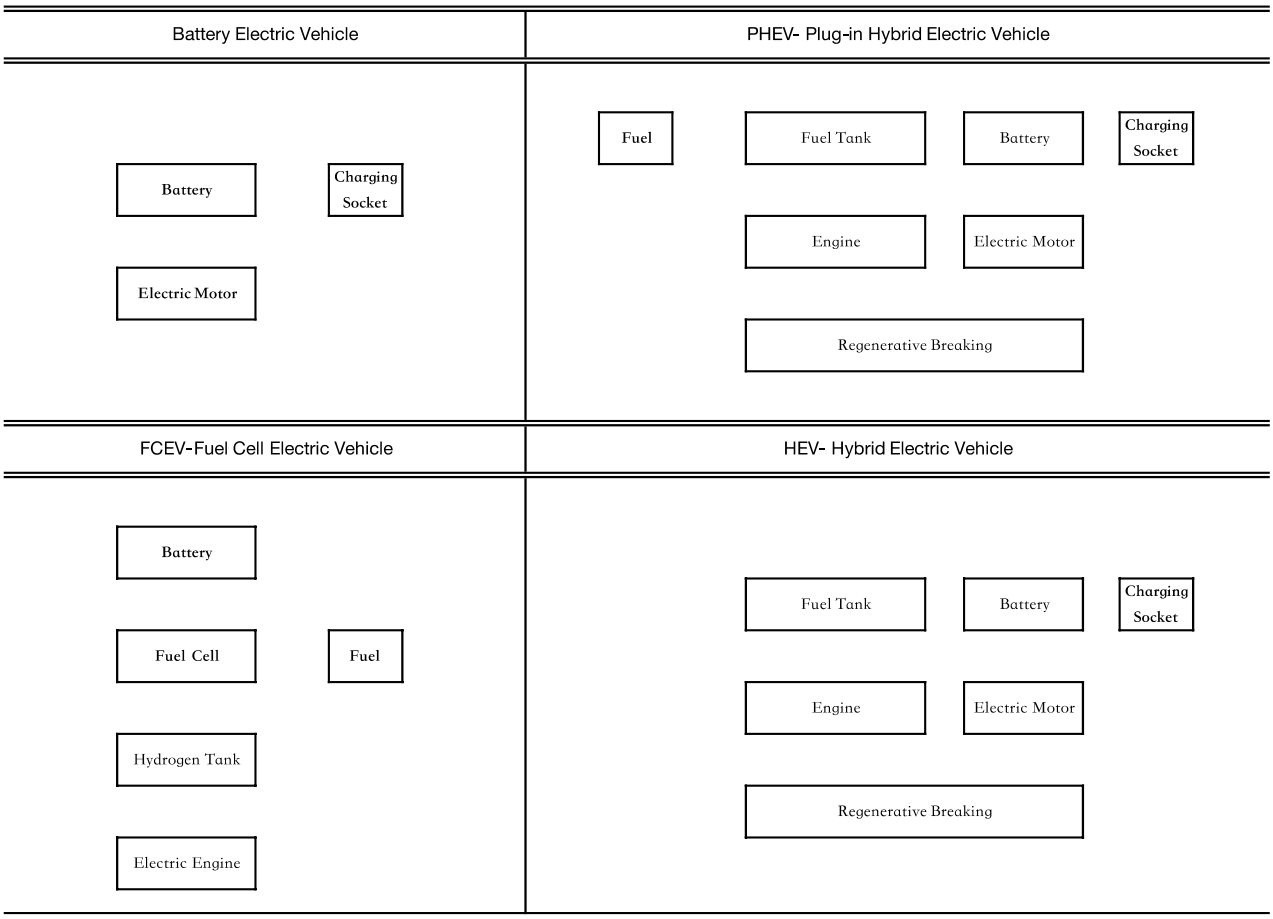

Figure 1. Structural diagram according to electric vehicle classification.

These diverse categories of EVs cater to varied consumer preferences and offer alternative solutions to conventional fossil-fuel-dependent transportation, contributing to a more sustainable automotive landscape.

2.2. Styles of Car Design

A car's exterior design profoundly impacts individual preferences and the perception of car manufacturers, constituting a pivotal determinant in consumer purchasing decisions. Thus, automotive manufacturers must engage in comprehensive research and analysis to develop exterior designs that align with consumer needs and preferences [5].

In the automotive industry, technological advancements have paralleled significant evolution in exterior design. These changes transcend mere shifts in consumer aesthetic preferences; they are also influenced by changes in consumer lifestyles. As noted by Kim et al., 2009 [6], contemporary cars are not merely utilitarian products, but also serve as high-value reflections of users' personalities and preferences. Present-day consumers prioritize not only design, but also emotional fulfillment. Park (2017) [7] underscores the importance of a design strategy that sustains ongoing emotional satisfaction for users, underscoring the pivotal role of design in all product categories. Consequently, automotive manufacturers continuously innovate to define their unique design languages, enhancing competitiveness and crafting automobile designs tailored to consumer preferences.

Gu (2021) [8] delineates the characteristic exterior styles of automobiles as per prominent automotive design management principles, as illustrated in Table 1 below.

Table 1. Car design style.

	Car Exterior Style Features		
1	Image focused on top quality and comfort	19	Image of an independent and strong personality
2	Image focused on dynamic technology and driving performance	20	Grotesque, future-oriented image emphasizing French sensibility
3	Practical technology and popular image	21	Emotional formative design
4	Emphasis on practicality and originality	22	Emphasizing sporty image
5	Design image that emphasizes future orientation and originality	23	Luxury and comfort realized with the best technology
6	Image of a comfortable, high-performance luxury sports car	24	Image reflecting the concepts of mass production and popularity
7	Image focused on safety and practicality	25	Emphasizes geometric tendencies from organic tendencies
8	Image focused on technology and practicality	26	Design that emphasizes dynamic and powerful images
9	Pursuing tradition and dynamism	27	Massive front section, vertical tail lamps, streamlined design
10	Pursuing individuality rooted in history	28	Emphasis on practicality and robustness
11	Pursuing the image of a comfortable traditional luxury car	29	Pursuing American-style decorative design and luxury
12	Group's image centered on sturdiness and practicality	30	Tendency to pursue strong individuality
13	Solid vehicle image	31	Overseas market-focused strategy that shifts from universality to specificity
14	Pursuing design that emphasizes emotional tendencies	32	Increase in emotional design
15	Pursuing individuality that emphasizes geometric images and metallicity	33	Unified image across vehicle types and emphasis on individuality for each vehicle type
16	Organic and colorful formative image	34	Emphasis on a design image based on emotion and expression
17	Geometric and concise functional formative image	35	Emphasizing the uniqueness, creativity, and impression of the brand
18	Tendency to gradually pursue individuality	36	Pursuing abstract formative design with the motif of the eyes and muscles of a wild beast

Meanwhile, pure electric vehicles, which can be manufactured and produced using simplified principles, have garnered significant interest from electric vehicle manufacturers in the Chinese market. Furthermore, in response to the imperative to mitigate air pollution and environmental concerns, the Chinese government actively advocates for the adoption of eco-friendly pure electric vehicles. Supported by favorable policies and infrastructure development initiatives, pure electric vehicles are experiencing rapid proliferation in China. Consequently, research on electric vehicle exterior design is burgeoning in the country, with numerous studies analyzing emerging design trends.

Wang et al., 2019 [9] categorized the exterior design of electric vehicles into two main types: adaptations of conventional internal combustion engine car styles and entirely new electric car styles. In a detailed analysis of the front section, the trend of electric vehicle design was dissected into four primary elements: grille, wheels, headlamps, and parametric design. Ji et al., 2022 [10] conducted a quantitative analysis of the proportion of grille and headlamp areas relative to the total front area of electric vehicles, while Li et al., 2020 [11] investigated various front-end elements such as grilles, bonnets, bumpers, headlamps, and wheels to discern exterior design trends in pure electric vehicles.

Wang, Y (2015) [12] and Wang et al., 2015 [13] delineated front-end elements such as bumpers, grilles, bonnets, headlamps, and fog lights in the exterior design of domestic electric vehicles. Yin (2021) [14] explored front design features encompassing headlamps, grilles, and fog lights in their study on electric vehicle design. Li et al., 2019 [15] classified car fronts according to formative features like headlamps, grilles, fog lamps, and air intakes, while Ren et al., 2022 [16] focused on dissecting front-end design features including grilles and headlamps.

During foreign studies, Button, Quinn E. (2019) [17] scrutinized front-end design elements such as headlamps, bonnets, bumpers, and side mirrors in electric vehicles. In a Korean study, Byun (2023) [18] categorized the front-end design elements of autonomous

vehicles into headlamps, grilles, and bumpers. Lee et al., 2008 [19] likened the front portion of a car to a human face, analyzing the formative characteristics of each element by drawing parallels between the headlamp and human eye, the radiator grille and human nose, and the air intake hole and human mouth. It was suggested that varying facial expressions akin to humans could be achieved based on proportional changes in the size, position, and shape of these elements.

Through focus group interviews (FGIs) involving five experts, five front-end elements and their corresponding ten semantic meanings were identified and organized according to design style types, as depicted in Table 2. These insights were derived from a researcher specializing in industrial design, based on a comprehensive review of prior research.

Table 2. Five elements and 10 design styles.

Front Element				
1. Bonnet	2. Headlamp	3. Grille	4. Side mirror	5. Bumper
Design style type				
1. Traditional style 6. Sporty style	2. Emotional style 7. Original style	3. Dynamic style 8. Simple style	4. Geometric style 9. Gorgeous style	5. Unique style 10. Futuristic style

We conducted focus group interviews to organize example images by type, categorizing them into types A and B, as illustrated below in Figure 2. To eliminate any extraneous influences apart from the exterior design, the brand emblems were removed from all vehicle examples belonging to types A and B. Additionally, the vehicle colors were standardized to black and white, and the background was removed.

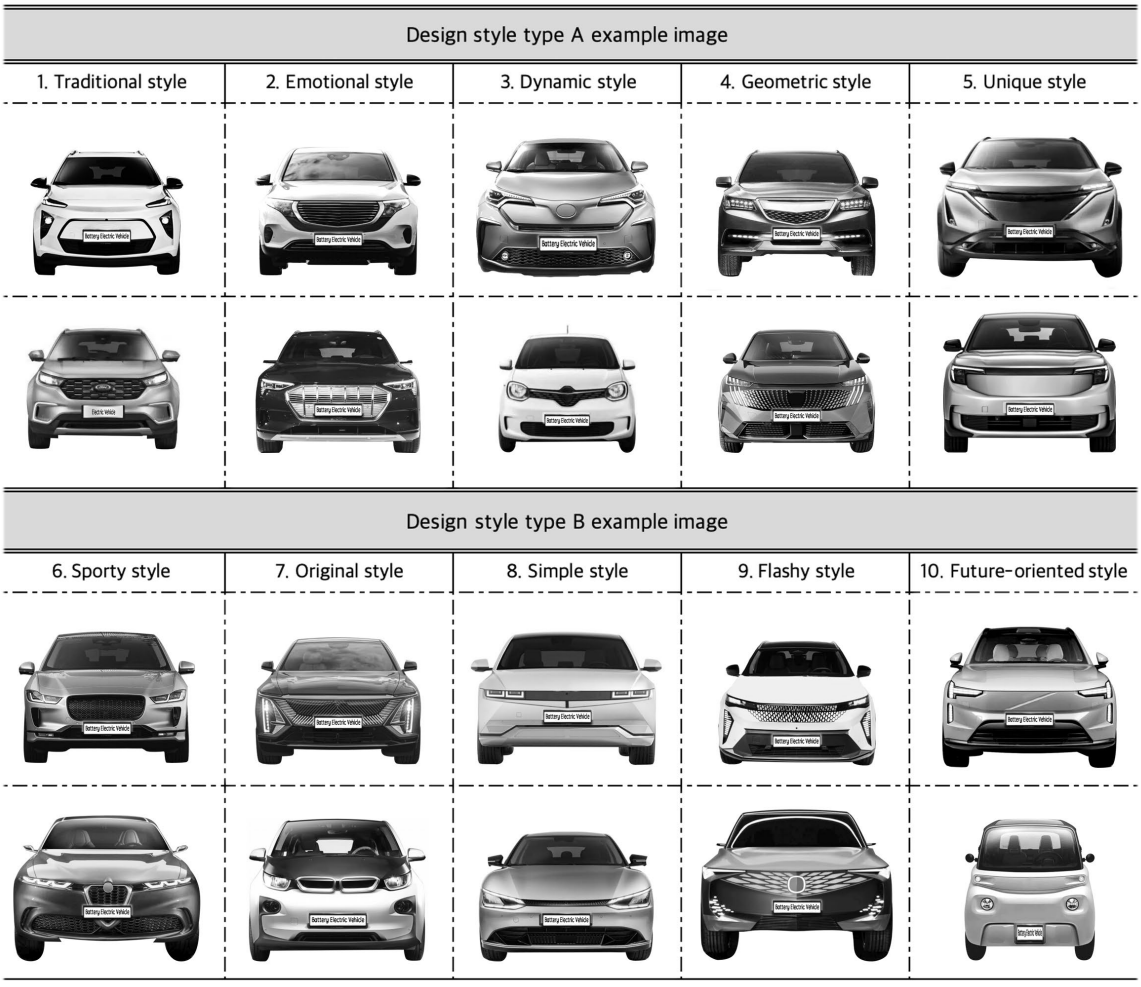

Figure 2. Example images.

3. Research Methods

3.1. MaxDiff Research Method

Maximum Difference Scaling (MaxDiff) [20], developed by Jordan Louviere in 1987 at the University of Alberta, Canada, is a consumer preference measurement technique. It involves evaluating various attributes through comparative assessment. This technique enables the identification of preferences and the calculation of the importance value of each attribute using a ratio scale. Respondents are presented with a questionnaire containing attributes to be evaluated and are asked to rank them from most preferred (best) to least preferred (worst). By making choices, a priority order can be derived.

Given that this study focused on preference surveys regarding front design elements, each design style was compared and analyzed based on five elements: headlamp, bonnet, bumper, grille, and side mirror, which were derived from previous research.

3.2. Data Collection

This study utilized the MaxDiff measurement technique to survey five front elements and 10 car design style types derived from previous research. A preliminary survey was conducted by 12 survey experts over a two-month period from November to December 2023. Subsequently, the questionnaire was revised and supplemented. The revised questionnaire was distributed and administered from 11 January to 5 February 2022, targeting adult men and women aged 20 or older in Korea. The survey was conducted by disseminating the survey link through survey leaflets, resulting in the collection of a total of 264 responses over 25 days. After excluding 44 inappropriate questionnaires, 220 valid samples were obtained.

The demographic analysis of the respondents revealed that among the 220 participants, 129 were men (58.6%) and 91 were women (41.4%). The majority of the respondents were in their 20s, accounting for 86 individuals (39.1%), followed by those in their 30s with 60 respondents (27.3%), in their 40s with 50 respondents (22.7%), in their 60s with 15 respondents (6.8%), and in their 50s with 4 respondents (1.8%). Regarding income level, the largest proportion of respondents earned between KRW 4 and 6 million per month, comprising 100 individuals (45.5%), followed by KRW 1 to 2 million (61 individuals, 27.7%), KRW 6 to 8 million (22 individuals, 10.0%), and others (21 individuals, 9.5%), with KRW 2 to 4 million earners comprising 16 individuals (7.3%).

In terms of residential environment, villas were the most common type of residence, with 157 respondents (71.4%), followed by officetels (28 individuals, 12.7%), apartments (15 individuals, 6.8%), single-family homes (13 individuals, 5.9%), and other types (7 individuals, 3.2%). Additionally, 160 respondents (72.7%) reported owning a vehicle, and 154 respondents (70.0%) expressed willingness to purchase an electric vehicle, as illustrated in Table 3.

Table 3. Demographic characteristics.

ASSORTMENT	DIVISION	FREQUENCY	PERCENT
GENDER	Male	129 people	58.6%
	Female	91 people	41.4%
AGE	20s	86 people	39.1%
	30s	60 people	27.3%
	40s	55 people	25%
	50s	4 people	1.8%
	Over 60	15 people	6.8%
MONTHLY INCOME	1~2 million KRW	61 people	27.7%
	2~4 million KRW	16 people	7.3%
	4~6 million KRW	100 people	45.5%
	6~8 million KRW	22 people	10%
	Other	21 people	9.5%

Table 3. *Cont.*

ASSORTMENT	DIVISION	FREQUENCY	PERCENT
LIVING ENVIRONMENT	Villa	157 people	71.4%
	Officetels	28 people	12.7%
	Apartment	15 people	6.8%
	House	13 people	5.9%
	Other	7 people	3.2%
VEHICLE OWNERSHIP	Yes	160 people	72.7%
	No	60 people	27.3%
DRIVING FREQUENCY	Less than once a week	53 people	24.1%
	3 times a week	81 people	36.8%
	5 times a week	39 people	17.7%
	7 times a week	47 people	21.4%
ELECTRIC VEHICLE DRIVING EXPERIENCE	Yes	98 people	44.5%
	No	122 people	55.5%
INTENTION TO PURCHASE ELECTRIC VEHICLE	Yes	154 people	70%
	No	66 people	30%

4. Research Methods

The collected questionnaires were analyzed using SPSS 2 7.0, and cross-analysis and MaxDiff analysis were conducted to examine the preferences for pure electric vehicle styles and the front element. Additionally, based on the results of a consumer design preference survey, future electric vehicle design trends were predicted.

4.1. Electric Vehicle Design Style Preference

O Johansson-Stenman and Martinsson (2006) [21] found that consumers tend to buy products that contribute to their self-image, indicating that their purchases are driven by a desire to uphold or enhance this self-perception.

This study used frequency analysis to conduct a comparative analysis to determine user preferences [22,23]. The 10 design styles previously derived were evaluated by categorizing them into Types A and B. Upon reviewing the results, among Type A respondents, the emotional style emerged as the most preferred, with 81 individuals (36.8%) favoring it, among whom 43 (53.1%) were female. The dynamic style followed closely, with 54 respondents (24.5%), of whom 42 (77.8%) were male, indicating a higher preference among men. Traditional style garnered the preference of 44 individuals (20.0%), while the geometric style appealed to 28 respondents (12.7%). The ratio of men to women for these two styles was similar. A unique style was favored by thirteen individuals (5.9%), of whom eight (61.5%) were men.

Among Type B respondents, the original electric car style was the most preferred, with 96 in dividuals (43.6%) opting for it, among whom 52 (57.1%) were female. The sporty style was favored by 57 respondents (25.9%), predominantly comprising men (39 respondents, 68.4%). The flashy style attracted 35 individuals (15.9%), with 27 (77.1%) being men. The simple style appealed to 29 participants (13.2%), predominantly males, with 18 (62.1%). Lastly, the future-oriented style had the lowest preference, chosen by only three individuals (1.4%), as depicted in Table 4 and Figure 3.

Table 4. Design preference by type.

Style	Type	Gender	Total	
		Female	Man	
A	Traditional style	19 (43.2%)	25 (56.8%)	44 people
	Emotional style	43 (53.1%)	38 (46.9%)	81 people
	Dynamic style	12 (22.2%)	42 (77.8%)	54 people
	Geometric style	12 (42.9%)	16 (57.1%)	28 people
	Unique style	5 (38.5%)	8 (61.5%)	13 people
B	Sporty style	18 (31.6%)	39 (68.4%)	57 people
	Original style	52 (54.2%)	44 (45.8%)	96 people
	Simple style	11 (37.9%)	18 (62.1%)	29 people
	Gorgeous style	8 (22.9%)	27 (77.1%)	35 people
	Futuristic style	2 (66.7%)	1 (33.3%)	3 people

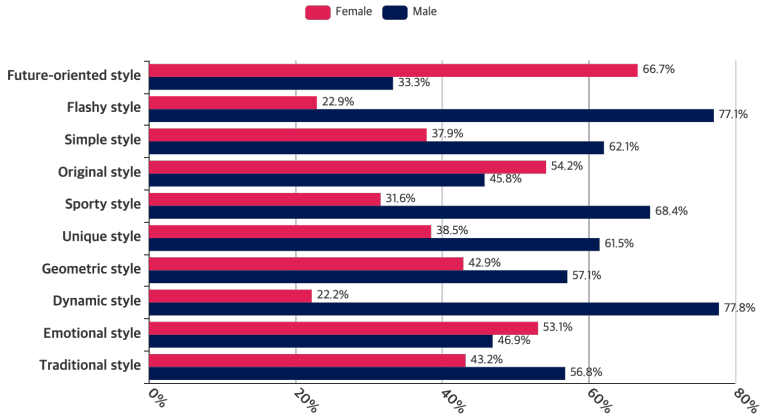

Figure 3. Comparison of male and female ratios by type.

Based on the analysis of the data from potential consumers with purchase intentions among Types A and B, it is evident that the original style garnered the highest preference, with 64 individuals expressing a preference for it. Following closely behind were 59 individuals who favored the emotional design, and 40 individuals who preferred the sporty style. Conversely, the future-oriented style garnered the fewest preferences, with only one person expressing a preference for it. This suggests that general consumers do not tend to readily opt for future-oriented styles, as depicted in Figure 4.

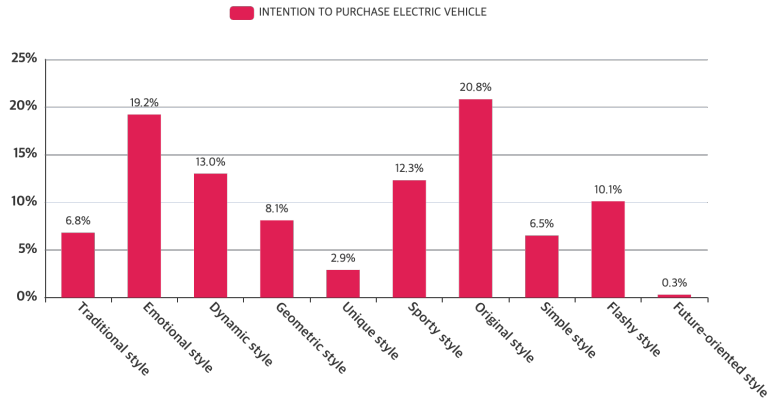

Figure 4. Analysis of potential consumer preferences.

4.2. Analysis of Preference for Electric Vehicle Design Style Based on Gender and Age

According to a consumer survey conducted by MORI in 2005 on behalf of Euro NCAP, there may be variances in the vehicle purchase process based on age and gender [24].

The results from Brenda H. Vrkljan's (2011) research suggest that specific vehicle attributes hold greater significance than others in the car-purchasing decision-making process. Furthermore, these preferences for particular features may fluctuate depending on the driver's age and gender.

Therefore, in this study, the questionnaire was analyzed according to gender and age. We investigated preferences regarding front design elements and sought to determine which of these elements consumers prioritize when purchasing a car. The analysis revealed that bonnets were the most preferred element, with 65 individuals (29.5%) expressing a preference for them. Among them, men constituted the majority, with 34 individuals (52.3%). Headlamps followed closely behind, preferred by 63 individuals (28.6%), with 48 men (76.2%) expressing a preference for them. Bumpers were favored by 59 individuals (26.8%), with a higher preference observed among women, with 37 individuals (62.7%). In contrast, the grille garnered the preference of 32 individuals (14.5%), while the side mirror exhibited the lowest preference, with only one person (0.5%) expressing a preference for it, as depicted in Figure 5.

Among people in their 20s, headlamps were the most popular element, with 33 people (38.4%) expressing a preference for headlamps. Next, bumpers were preferred by 24 people (27.9%), and 21 people (24.4%) liked the hood. The grille received the preference of eight people (9.3%). In comparison, the most popular element for respondents in their 30s was the bonnet, with 22 people (36.7%); the second most popular element was headlamps, with 15 people (25%), followed by the grille (12 people) and bumper (11 people). Among those in their 40s, bumpers were generally more popular, with 22 people (40%) opting for this element, followed by the bonnet (13 people, 23.6%) and headlamps (12 people, 21.8%). Seven people (12.7%) said they liked the grille, and only four people in their 50s responded, all of whom preferred the bonnet. Among the fifteen respondents in their 60s or older, five (33.3%) preferred the bonnet, five (33.3%) liked the grille, and three (20%) liked the headlamps. Two respondents (13.3%) liked the bumpers, and side mirrors had the lowest preference, with only one person in their 40s showing a preference for this feature, as depicted in Table 5.

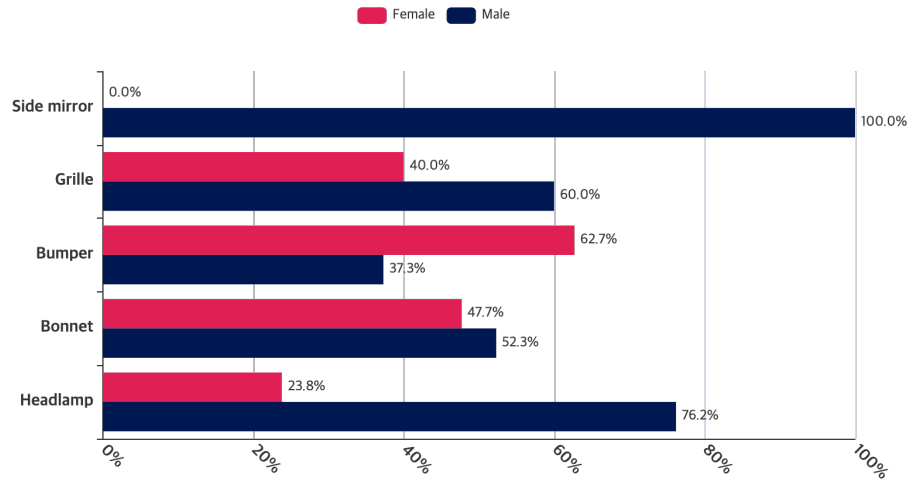

Figure 5. Comparison of male and female preferences by front design element.

Table 5. Comparison of age preferences by front design element.

Element	20s	30s	40s	50s	Over 60s
Headlamp	33 people	15 people	12 people	None	3 people
Bonnet	21 people	22 people	13 people	4 people	5 people
Bumper	24 people	11 people	22 people	None	2 people
Grille	8 people	12 people	7 people	None	5 people
Side mirror	None	None	1 people	None	None

Next, in examining the results from our analysis using the MaxDiff preference measurement method, we observed the following trends:

For headlamps, the preference for traditional design stood at 6.3%, emotional design at 18.1%, dynamic design at 2.3%, and geometric design at 2.3%. The preferences for unique design, sporty design, original design, simple design, colorful design, and future-oriented design were 5.0%, 11.6%, 13.5%, 11.1%, 13.8%, 6.7%, and 11.6%, respectively. Among these, emotional design had the highest preference at 18.1%, while dynamic design had the lowest at 2.3%.

In the case of bonnets, the preferences were as follows: traditional design at 7.1%, emotional design at 3.6%, dynamic design at 5.5%, geometric design at 6.9%, unique design at 10.4%, sporty design at 14.7%, original design at 10.2%, simple design at 21.2%, flashy design at 5.6%, and future-oriented design at 14.7%. Notably, simple design had the highest preference at 21.2%, whereas emotional design had the lowest at 3.6%.

Regarding bumpers, the preferences were distributed as follows: traditional design at 10.4%, emotional design at 15.1%, dynamic design at 3.3%, geometric design at 6.2%, unique design at 9.8%, sporty design at 14.2%, original design at 6.9%, simple design at 17.6%, flashy design at 5.8%, and future-oriented design at 10.8%. Simple design was the most preferred at 17.6%, while dynamic design had the lowest preference at 3.3%.

For grilles, the preferences were as follows: traditional design at 8.0%, emotional design at 4.5%, dynamic design at 5.1%, geometric design at 7.1%, unique design at 13.0%, sporty design at 15.2%, original design at 12.5%, simple design at 16.1%, flashy design at 6.8%, and future-oriented design at 11.8%. Simple design garnered the highest preference at 16.1%, whereas emotional design had the lowest at 4.5%.

Finally, the side mirror preferences were distributed as follows: traditional design at 8.0%, emotional design at 6.4%, dynamic design at 6.9%, geometric design at 6.3%, unique design at 10.0%, sporty design at 13.1%, original design at 10.1%, simple design at 19.8%, flashy design at 6.3%, and future-oriented design at 13.6%. Simple design was the most preferred at 19.8%, while geometric design had the lowest preference at 6.3%, as depicted in Figure 6.

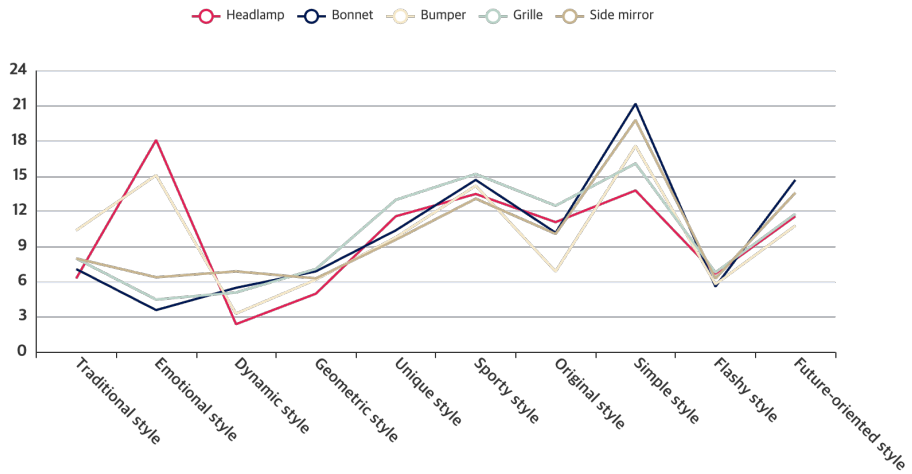

Figure 6. Preferences for each front design element.

5. Discussion

Charlie Ranscombe (2012) [25] presented a technique to investigate the influence of aesthetic features and the brand recognition of vehicles. Appearance has been shown to impact significantly on consumers' perception of products.

Therefore, regarding the overall exterior design of pure electric vehicles, our study aims to analyze consumer preferences through a comparative evaluation of various design styles. By examining the extent of preference differences for each element, we sought to identify which styles influence preferences and which styles are favored by consumers for each element.

5.1. Research Highlights

5.1.1. Five Elements

Upon analyzing the preferences for each design element, we observed a consistent preference for simple design across all elements. Notably, the bonnet emerged as the most crucial element, likely reflecting a desire for an easy distinction between electric vehicles and internal combustion engine vehicles. Given the absence of a complex powertrain system, the bonnet of electric vehicles can potentially serve as a trunk, necessitating a new, simplified design approach.

Bumpers garnered increased importance, particularly among women, as they serve to protect the vehicle body in collisions with other vehicles or pedestrians. In contrast, grilles and side mirrors are becoming less attractive to consumers, possibly due to technological advancements diminishing their significance.

Conversely, headlamps are gaining prominence for their ability to create various atmospheres and offer driving assistance functions, drawing consumers' attention. Notably, there appears to be a trend whereby men prioritize design aesthetics more than women, with an inclination towards emotional design.

5.1.2. Ten Design Types

Our findings indicate that, in a comparative analysis of the overall image of electric vehicles across 10 design types, both men and women exhibited a preference for the original style. This suggests a consumer demand for innovative exterior designs. Furthermore, upon deeper examination, it became evident that men tend to favor a more dynamic style, while women lean towards a more emotional aesthetic.

The original style emerged as the most preferred exterior design style for electric vehicles, with women exhibiting a particular preference for it over men. Conversely, future-oriented styles were not notably favored. Additionally, the study highlighted the significance of the bonnet and headlamp design as primary considerations for consumers when purchasing an electric vehicle.

Overall, our study provides valuable insights into consumer preferences for the exterior design of pure electric vehicles, highlighting the importance of simplicity, innovation, and functionality in meeting consumer demands, as depicted in Figure 7.

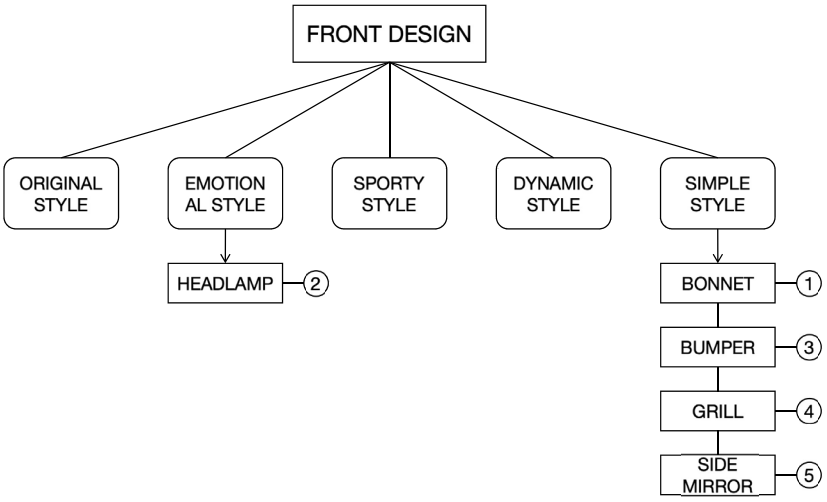

Figure 7. Preference for the front design of electric vehicles. (The numbers 1–5 in image are the order of preference).

5.1.3. Differences in Gender and Age

The findings of this study align with those of Brenda H. Vrkljan's (2011) [26] research. It reveals that significant variations in preferences exist due to gender, age, and other factors. For instance, men tend to favor sleek and dynamic designs, whereas women prefer designs

that prioritize perception. Regarding age, younger individuals tend to gravitate towards design elements that accentuate perception, such as headlamps. Conversely, as individuals age, their focus shifts towards safety-related features like bumpers or bonnets.

5.1.4. Comparison Results

This study diverges from Andre Liem's (2009) [27] research, which delves into designers' viewpoints regarding the typical characteristics of formal treatment in automotive styling, as conveyed through adjectives describing mood. Unlike Liem's study, this research enables consumers to make objective assessments and draw conclusions based on the description of form. This aspect serves as a notable highlight of the current study.

5.2. Social Influence

As environmental pollution continues to worsen, public awareness regarding environmental issues has heightened. The integration of renewable energy into electric vehicles stands as a significant step toward ameliorating our polluted environment (e.g., Francisco et al., 2017 [28]; Hawkins et al., 2012 [29]). After reviewing numerous studies on electric vehicles (EVs), it was determined that EVs powered by electricity from sources with lower global warming potentials (GWPs) are superior to internal combustion engine vehicles (ICEVs). Consumer concerns for eco-friendly lifestyle (e.g., Hidrue et al., 2011 [30]) eco-friendly attitude (e.g., Carley et al., 2013 [31]), and the environment (e.g., Sang and Bekhet, 2015 [32]) play important roles in the decision to purchase an electric vehicle.

Research conducted in Norway demonstrated that electric vehicles (EVs) contribute to a reduction in global warming potential (GWP) within the country. This is attributed to the predominant use of hydropower as the primary source of electricity in Norway (e.g., Singh and Strømann, 2013 [33]).

Electric vehicles have been actively promoted by governments in various countries, with many countries choosing them as an environmental protection measure. In March 2009, as part of its auto industry adjustment and revitalization policies, China set a short-term goal for alternative fuel vehicles (AFVs) to produce 500,000 electric vehicles (EVs) by 2011. In addition, the "Energy Saving and New Energy Vehicle Development Plan (2011–2020)" led by the Ministry of Industry and Information Technology formulated the long-term national strategy for China's new energy vehicle industry [34].

5.3. Limitations and Future Research

5.3.1. Limitations of This Study

A limitation of this study is its failure to adequately reflect the diversity of design styles. While the study primarily identified original and emotional styles, future research should encompass a broader range of design options to better understand consumers' diverse tastes and develop designs that cater to varied market demands. Additionally, this study exclusively concentrated on Korean participants, overlooking the significant influence of cultural background on consumers' perceptions of product design. As highlighted by Lee et al., 2017 [35], cultural factors play a crucial role in shaping consumer preferences. Therefore, it is imperative to examine the impact of culture on consumers' evaluations of product design from a global perspective, as emphasized by Gil et al., 2017 [36].

5.3.2. Implications of the Study

Charlie R et al.'s (2017) [25] research findings highlight the significance of car styling, with 49% of participants rating it as "very important" in their car purchasing decisions, while 43% considered it "somewhat important" and 8% deemed it "not important." This underscores the crucial role of car styling in consumer preferences. As electric vehicles necessitate fewer cumbersome parts, an increasing number of companies, including China's Xiaomi and emerging enterprises like South Korea's JJmotors, are venturing into the development of the electric vehicle industry. Especially for these companies lacking extensive production and sales experience, aesthetic appeal becomes paramount. This study has

proactively identified current consumer needs and preferences, offering valuable insights for these emerging companies and paving the way for their development. Building on this research, future investigations will delve into a global examination of design preferences, with a focus on cultural influences. By exploring and comparing differences in preferences across different countries, we aim to gain a comprehensive understanding of consumer needs and the impact of styling design on purchase intentions.

6. Conclusions

The significance of this study lies in its analysis of consumer preferences aimed at revitalizing the declining pure electric vehicle market. The findings offer valuable insights to developers in the process of technology development, providing crucial information on consumer preferences to guide the creation of new pure electric vehicle designs.

In summary, this study conducted a survey on the preference for front elements in the exterior design of electric vehicles and analyzed these preferences, leading to four key conclusions.

Firstly, the comparison of preferences between men and women revealed that both genders favor original designs, albeit with women showing a tendency towards emotional styles and men towards dynamic styles.

Secondly, through a comparison of age-related preferences, it was found that the younger the age, the more emotional the person is, and the older the person is, the more they pay attention to safety.

Thirdly, the analysis of design-type preferences for front elements using the MaxDiff preference measurement method identified the simple design as the most preferred across all elements. Furthermore, a significant number of respondents expressed a preference for emotional designs, particularly for headlamps and bumpers.

Finally, it is known that appearance plays an important role in the successful sale of products (Bloch, 1995 [37], Moulson and Sproles, 2000 [38], Page and Herr, 2002 [39]). Audi states that up to 60% of a consumer's decision to purchase a vehicle is based on style rather than technical performance (Kreuzbauer & Malter, 2005 [40]). Many studies show that both product appearance and brand can influence consumers' judgments. Therefore, through this study, future research directions may include the following approaches:

(1) Identify sales groups and create different designs for each group.
(2) Understand the preferences of current consumer groups and create designs that suit them.
(3) Emphasize emotional design and develop differentiated strategies to cater to diverse consumer preferences.
(4) Acknowledge that a simpler design, focusing on minimalistic details, may garner more popularity compared to an overly intricate design.

With the popularization of technology, consumers' perception of car use has changed from a means of mobility to a consumer experience in the process of mobility. The concept of electric vehicles has gradually evolved from "transportation" to "electronic products". Despite the fact that Apple, the leader in the electronics industry, has given up its 10-year electric vehicle research and development plan, as a renewable resource powered by electricity, the advantages of electric vehicles will never be diminished. On the contrary, with the increasing scarcity of resources, electric vehicles will certainly become the main means of mobility in the future.

Looking ahead, as sustainability and environmental friendliness gain prominence in the automotive industry, future research should explore sustainable materials and production methods alongside design styles. By developing sustainable designs, the environmental impact of vehicles can be minimized, aligning with consumer preferences for environmentally conscious products. Through these additional research directions, new insights and innovations can be realized in the field of automotive design.

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References

1. Statista Research Department. Electrified and Battery Electric Vehicle Sales as a Percentage of Car Sales Worldwide between 2020 and 2025. Available online: https://www.statista.com (accessed on 28 July 2023).
2. Kroea Automobile & Mobility Association. Number of Pure Electric Vehicles (EV) Sold. Available online: https://www.kama.or.kr (accessed on 14 October 2023).
3. Kang, H.-M.; Park, S.-M.; Kwon, J.-W. Diversification Tendency of Appearance Design for High-rise Office Buildings in Korea. *J. Reg. Assoc. Archit. Inst. Korea* **2018**, *20*, 67–74.
4. Cho, W.C. A Study on a Style of NEV(Neighbor Electric Vehicle) for Sustainable Society. *Korean Soc. Sci. Art* **2012**, *10*, 211–221. [CrossRef]
5. Lee, M.Y. Recognition Properties for the Attractive Exterior Design of Passenger Cars—Proposal for the recognition model by measuring user characteristics in car design. *Bull. Korean Soc. Basic Des. Art* **2017**, *18*, 291–305.
6. Kim, B.-A.; Oh, H.-J.; Suk, H.-J. The Correlation between Emotional Congruency of Car Exterior and the Preference. *KSDS Conf. Proceeding Korean* **2009**, 30–31.
7. Park, K.-J. A study of product value continuity by comparing purchasing value and use value. *Korean Soc. Sci. Art* **2017**, *31*, 149–156. [CrossRef]
8. Gu, S. *Mobility Design Textbook*; Ahn Graphics & book publishers: Gyeonggi-do, Republic of Korea, 2021; 340p.
9. Wang, B.; Geng, S. Research on the development trend of exterior styling design of electric vehicles. *J. Automot. Eng.* **2019**, *4*, 285–293.
10. Ji, Z.; Han, T. Research on the relationship between electric vehicle front face shape and user perception preference. In Proceedings of the 2022 China Society of Automotive Engineering Annual Conference (2), Shanghai, China, 1–10 November 2022; pp. 331–337.
11. Li, Y.; Wu, Y. Research on influencing factors and feature design trends of pure electric vehicle exterior styling. *Packag. Eng.* **2020**, *6*, 72–80.
12. Wang, Y. Research on Exterior Styling Design of Household Electric Vehicle Body. Master's Thesis, Yanshan University, Qinhuangdao, China, 2015.
13. Wang, Y. Household Electric Vehicle Body Appearance Design Research. Master's Thesis, Yanshan University, Qinhuangdao, China, 2015.
14. Yin, L. Research on Electric Vehicle Front Face Design Driven by User Image. Master's Thesis, Jiangsu University, Zhenjiang, China, 2021.
15. Li, J.; Zhou, L. Research on the development trend of electric vehicle front face modeling based on parametric description. In Proceedings of the 2019 China Society of Automotive Engineering Annual Conference, Beijing, China, 25 October 2019; pp. 416–421.
16. Ren, M. Research on front exterior styling design of micro electric vehicles in the new context. *J. Jingdezhen Univ.* **2022**, *06*, 101–104.
17. Button, Q.E. The Influence of Exterior Design Attributes on Consumer Preference for Electric Vehicles. Ph.D. Thesis, Oklahoma State University, Stillwater, OK, USA, 2019.
18. Byun, Y.J. Analysis of modeling design change factors of autonomous electric vehicles—Focusing on the front design change by using the autonomous driving system. *Treatise Plast. Media* **2023**, *26*, 271–279. [CrossRef]
19. Lee, K.; Choi, K.W. An Observation on the Expression Factors in Automotive Frontal Exterior Designs. *Arch. Des. Res.* **2008**, *21*, 35–45.
20. Louviere, J.J. What you don't know might hurt you: Some unresolved issues in the design and analysis of discrete choice experiments. *Environ. Resour. Econ.* **2006**, *34*, 173–188. [CrossRef]
21. Johansson-Stenman, O.; Martinsson, P. Honestly, why are you driving a BMW? *J. Econ. Behav. Organ.* **2006**, *60*, 129–146. [CrossRef]
22. Kim, S.U.; Lee, K.S. Regional low flow frequency analysis using bayesian multiple regression. *J. Korea Water Resour. Assoc.* **2008**, *41*, 325–340. [CrossRef]

23. Wang, Q.A.; Liu, Q.; Ma, Z.G.; Wang, J.F.; Ni, Y.Q.; Ren, W.X.; Wang, H.B. Data interpretation and forecasting of SHM heteroscedastic measurements under typhoon conditions enabled by an enhanced Hierarchical sparse Bayesian Learning model with high robustness. *Measurement* **2024**, *230*, 114509. [CrossRef]
24. Market, Opinion Research International [MORI]. 2005. Available online: https://www.morichile.cl (accessed on 10 April 2024).
25. Ranscombe, C.; Hicks, B.; Mullineux, G.; Singh, B. Visually decomposing vehicle images: Exploring the influence of different aesthetic features on consumer perception of brand. *Des. Stud.* **2012**, *33*, 319–341. [CrossRef]
26. Vrkljan, B.H.; Anaby, D. What vehicle features are considered important when buying an automobile? An examination of driver preference by age and gender. *J. Saf. Res.* **2011**, *42*, 61–65. [CrossRef] [PubMed]
27. Liem, A.; Abidin, S.; Warell, A. Designers' perceptions of typical characteristics of form treatment in automobile styling. In Proceedings of the 5th International Workshop on Design & Semantics of Form and Movement, Taipei, Taiwan, 26–27 October 2009; DesForm: Hong Kong, China, 2009; pp. 144–155.
28. Choma, E.F.; Ugaya, C.M.L. Environmental impact assessment of increasing electric vehicles in the Brazilian fleet. *J. Clean. Prod.* **2017**, *152*, 497–507. [CrossRef]
29. Hawkins, T.R.; Gausen, O.M.; Strømman, A.H. Environmental impacts of hybrid and electric vehicles—A review. *Int. J. Life Cycle Assess.* **2012**, *17*, 997–1014. [CrossRef]
30. Hidrue, M.K.; Parsons, G.R.; Kempton, W.; Gardner, M.P. Willingness to pay for electric vehicles and their attributes. *Resour. Energy Econ.* **2011**, *33*, 686–705. [CrossRef]
31. Carley, S.; Krause, R.M.; Lane, B.W.; Graham, J.D. Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cites. *Transp. Res. Part D Transp. Environ.* **2013**, *18*, 39–45. [CrossRef]
32. Sang, Y.N.; Bekhet, H.A. Modelling electric vehicle usage intentions: An empirical study in Malaysia. *J. Clean. Prod.* **2015**, *92*, 75–83. [CrossRef]
33. Singh, B.; Strømman, A.H. Environmental assessment of electrification of road transport in Norway: Scenarios and impacts. *Transp. Res. Part D Transp. Environ.* **2013**, *25*, 106–111. [CrossRef]
34. Zhang, Y.; Yu, Y.; Zou, B. Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. *Energy Policy* **2011**, *39*, 7015–7024. [CrossRef]
35. Lee, S.; Johnson, Z.S. The effect of new product design and innovation on South Korean consumer's willingness to buy. *Asia Pac. J. Mark. Logist.* **2017**, *29*, 98–113. [CrossRef]
36. Gilal, N.G.; Zhang, J.; Gilal, F.G. Linking product design to consumer behavior: The moderating role of consumption experience. *Psychol. Res. Behav. Manag.* **2018**, *11*, 169–185. [CrossRef] [PubMed]
37. Bloch, P.H. Seeking the ideal form: Product design and consumer response. *J. Mark.* **1995**, *59*, 16–29. [CrossRef]
38. Moulson, T.; Sproles, G. Styling strategy. *Bus. Horiz.* **2000**, *43*, 45. [CrossRef]
39. Page, C.; Herr, P.M. An investigation of the processes by which product design and brand strength interact to determine initial affect and quality judgments. *J. Consum. Psychol.* **2002**, *12*, 133–147. [CrossRef]
40. Kreuzbauer, R.; Malter, A.J. Embodied cognition and new product design: Changing product form to influence brand categorization. *J. Prod. Innov. Manag.* **2005**, *22*, 165–176. [CrossRef]