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# Quantifying Influences on Perceived Design Age in Cars: A Conjoint Analysis

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**Abstract**

Industrial products are no longer bound by the sole dogma of "form follows function", as the customer must also be satisfied with the design. One aspect of product perception is the design age, a visible time stamp embedded in the form language and product shape. Previous research by Kießling et. al (2021) suggests that the perception of design age is independent of brand influences and can be based on knowledge as well as design. Our goal is to use the example of the automobile to explore which design-based influencing factors determine the subjective perception of the design age. Therefore characteristic design elements of the car are identified and evaluated in a conjoint analysis setting. The conjoint analysis includes the four attributes exterior body, radiator grille, headlights and colour with a total of 15 levels, which are combined into 16 stimulus patterns by means of an orthogonal design. The assembly is realised as image montages in Photoshop. By using these artificial car images, the knowledge-based influence can be minimised and is not considered further. The study is carried out as an online questionnaire and distributed among 205 participant, from which 202 valid data sets are obtained. The conjoint analysis is conducted in an aggregated form and for every individual using SPSS. For each level, a part-worth utility is calculated, which implies the strength and direction in which the design age is influenced. In addition, the relative importance of each attribute is determined. This shows that the headlights (33.1%) followed by the exterior body (29.2%) represent the main influences. The radiator grille (17.3%) and the colour scheme (20.4%) have a lower importance. The individual conjoint values are subsequently fed into a cluster analysis and divided into three clusters. The results indicate that the design elements differ in their strength of influence and that there are dominant factors such as the headlights. In addition, the clusters indicate that the participants of each group prefer varying design elements for the assessment of the design age and are predominantly guided by these elements. Therefore future design investments, as applied in car facelifting processes, may consider the actual impact and prioritize design features that positively influence design age, creating a more modern appearance.
***Keywords: design age, conjoint analysis, product perception***

# 1 Introduction

## 1.1 Perception of cars

Due to their constant presence in everyday life, product perception naturally plays a central role with cars. Thus, the automobile is attributed the greatest importance of all industrial products, because it decisively determines the appearance of our world and is also an expression of the user's personality (Tumminelli, 2006).
In terms of the visual presence and significance of vehicle design, the perception of vehicle form has been explored in numerous scientific studies. These include, in particular, analytical studies of the vehicle shape (Ranscombe 2012) and experimental studies of the vehicle shape focussing on attractiveness and friendliness (Holder 2016; Reid et al. 2010), visual perception with eye tracking (Chassy et al. 2015; Hyun et al. 2015) and aspects of brand perception (Fischer et al. 2021). All these aspects correlate more or less strongly with the perceived design age, which plays an important role in product perception and will be discussed below.

## 1.2 Design age

Kern and Maier (2020) find that even inanimate industrial objects are associated with a certain age. This design age is linked to the external physical form of the product and is determined by the zeitgeist and trends during product development. Kießling et al. (2021) show that the perception of age in automobiles corresponds to the chronological order of market introduction. In their experiment, brand labels and colour influences are retouched out of the stimulus patterns. Nevertheless, the subjects are able to correctly temporally classify cars based on exterior design, even without branding cues.
Our investigations intend to expand the research field of design age. In addition, we want to quantify the importance of individual design elements for the perception of the design age. For this purpose, the method of conjoint analysis, well established in market research, is transferred to industrial design engineering.

## 1.3 Overview of the conjoint analysis

Conjoint analysis originated in the work of Luce and Tukey (1964) and became one of the most important methods of modern market research in the following decades (Green et al. 2001). This preference measurement model assumes that product perception adds up from the individual effects of independent features. Each feature, called attribute can contain different levels. In the conjoint experiment, verbal, visual or real stimulus patterns from different combinations of these levels are presented. The participants evaluate each set via ranking or rating. The part-worth utility of individual levels calculates based on their repeated occurrence in differently combined and assessed stimulus patterns. The relative importance of the attributes results from the range of their levels' part-worth utilities (Hillig 2006).
Conjoint analysis is continuously gaining popularity in other research areas that seek to measure multifactorial preference. Halbey et al. (2018) address the acceptance of battery electric vehicles (BEV). Using conjoint analysis, they evaluate and compare charging infrastructure characteristics such as charging time, network density, location, and range. The accumulated data for single attributes helps to create highly preferred scenarios for future BEV usage.
Chen et al. (2007) and Kohler (2003) use conjoint analysis to evaluate individual features on automobiles focusing on styling perception. In the study by Chen et al. (2007), the radiator grille, the headlights, the side vents and the overall profile are modified. The recombinations are then assessed with regard to eleven bipolar adjective pairs. With the conjoint results, they provide an opportunity to manipulate design features for a specific affective response.

In his study, Kohler (2003) uses a decompositional approach to conduct a selection-based conjoint analysis of the importance of design attributes. The stimulus patterns contain two-dimensional vehicle representations in the side view with morphed proportions and dimensions. In contrast, the method used in this paper corresponds to a traditional conjoint analysis. Adaptations with regard to the stimuli presented, the evaluation process and the integration of further study elements relevant to market research, such as purchase intention, have led to a large number of methodological variants. A deeper insight into the topic is available in Rao (2014) or in Hillig (2006), among others. For a general overview, Green et al. (2001) is recommended. In addition to practical use cases out of the authors' work in the last 30 years, this publication also provides a list of influential contributors in the research area of conjoint analysis.

## 2 Methods

The conjoint method is implemented to determine the contribution of individual design elements in relation to the perception of design age. In the following, the structure of the conjoint analysis, the data collection, the creation of the stimulus patterns, and the questionnaire design are presented.

### 2.1 Structure of the conjoint analysis

To better illustrate our procedure, we look at the structure of the conjoint analysis in five sub-steps as shown in figure 1.

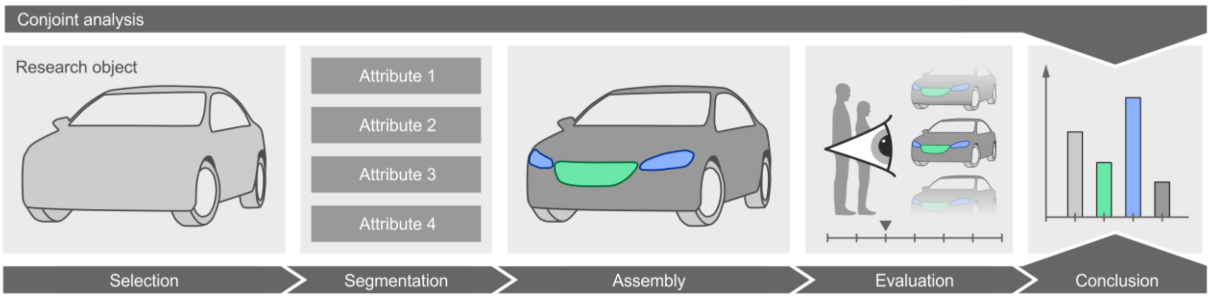


**Figure 1. Structure of conjoint analysis**

The first step is to select the test object. The automobile has a broad research history and is a classic example of a multi-generational industrial product. In addition, due to the presence in everyday life mentioned above, the car offers a high degree of familiarity in terms of product recognition.

In the segmentation step, formative, independent attributes are identified. Characteristic levels are determined for the respective attributes. Chapter 2.3 outlines which design attributes are relevant to vehicle design. The final selection of attributes includes the *exterior body*, the *headlights*, the *radiator grille* and the *colour*.

The individual levels are composed into new sets of stimulus pattern during the assembly phase. Depending on the number of levels, all mathematically possible combinations or a selection thereof can be generated. Mathematical methods such as orthogonal design, but also experimental approaches (Ikemoto and Yamaoka 2011) are available for reducing the number of stimulus patterns. In the study, the assembly is conducted in the form of a photomontage for each stimulus pattern.

In the fourth step, the stimulus patterns are distributed to a subject collective for evaluation. The stimulus patterns are presented in a uniform perspective and rated consecutively. In the following chapters, our specific survey settings are described more thoroughly.

In the last step of the conjoint analysis, the overall ratings are mathematically split and calculated back to the individual attributes and levels. For this purpose, the collected data is transferred to IBM SPSS Statistics 27 (SPSS) and analysed with the CONJOINT syntax.

## 2.2 Data collection and evaluation

When selecting the measurement model, we opted for the part-worth model and thus assume an additive linkage of the conjoint levels. The survey design is based on the full profile method, i.e. each stimulus pattern will always contain representatives of all attributes. For the test object car, a differing approach is not recommended, since missing attributes, as intended in the partial profile method, would visibly impair the technical integrity of the test object (e.g. missing headlights) and could influence the participants in a non-quantifiable way.
The four planned attributes and their levels (three to four each) require a reduced design in terms of stimulus patterns (see figure 2). A presentation of all possible combinations of levels would result in 192 stimulus patterns to be evaluated. This number is neither manageable in the preparation of the experimental material nor acceptable for the participants. With the help of an orthogonal plan, the number of stimulus patterns is reduced to 16. The SPSS function ORTHOPLAN automatically compiled the individual stimulus patterns.

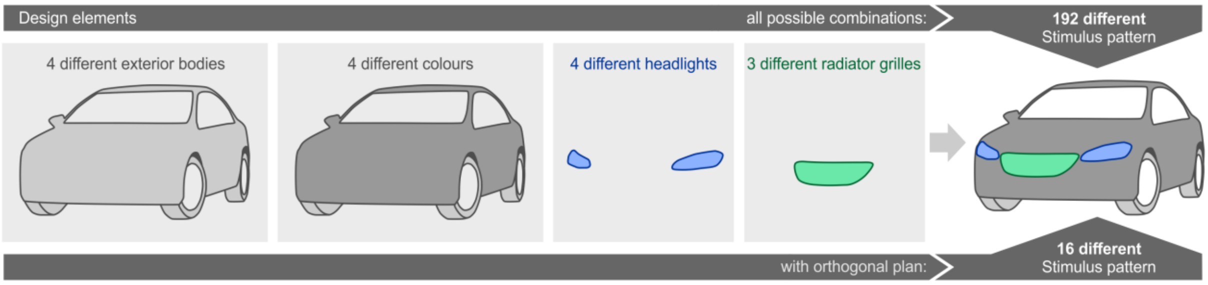


**Figure 2. Stimulus pattern reduction with ORTHOPLAN**

Each stimulus pattern is assessed via rating. For this, the participants answer the question of how old the design seems on a six-point scale from "rather old" (1) to "rather new" (6). The data is later submitted to aggregated and individual conjoint analyses. The calculations are carried out using the SPSS syntax function CONJOINT, which is based on the OLS algorithm. The individual results of the participants are utilised for further cluster analysis.

## 2.3 Stimulus pattern

The stimulus patterns were compiled from image material of different car models in Photoshop. In this process, we took care to maintain a uniform perspective and a neutral environment.

### *2.3.1 Exterior body*

As there are many research approaches concerning the automobile body (Hyun, 2015; Reid, 2010), the terms for this design element vary. Therefore Holder's systematic framework was used, defining the outer form as *exterior body*, which divides the vehicle into the front and rear sections (Holder 2016). The vehicle body of each section can be cubic (C), adaptive (A) or integral (I) and may represent in different combinations all common exterior bodies. The classic sedan corresponds to an AA exterior, while the compact class results from an AC combination. The study also included the IC exterior (van) and the AI exterior (coupe). To avoid brand influences in product perception, all visual materials shall originate from the same manufacturer. As Volkswagen offers a wide range of models with the required exterior bodies, all levels are based on this brand. To minimize unwanted influence of design age itself, models from a similar period were selected. They should not represent the latest series to avoid outshining the other conjoint levels. We therefore chose the Passat (2011), the Sharan (2011), the Scirocco (2009) and the Golf (2009).

#### *2.3.2 Headlights*

Several sources name the headlights as relevant design features, e.g. Liem et al. (2009). They act as "eyes" in perception and thus influence the perceived character of a car (Windhager et al. 2008 & 2010). The Headlights from the Golf series are used for the conjoint analysis. The different levels are from the 2009, 2013, 2017 and 2020 series.

#### *2.3.3 Radiator grille*

The radiator grille is often used as a trademark (Hyun et al. 2015) and is also functionally an important component of the vehicle and is therefore repeatedly part of scientific studies on product perception (Liem et al. 2009, Holder et al. 2018). The radiator grilles used are from the Passat series. The levels origin from 1996, 2006 and 2011. The distance in time between the radiator grilles is considerably greater than between the headlights. This is because there were only minor formal changes in the model generations of the 1990s and early 2000s. In order to ensure a clear allocation of the conjoint levels, we decided to include only clearly distinguishable representations.

#### *2.3.4 Colour*

By looking at the registration statistics of the Kraftfahrt-Bundesamt, we can see a base in achromatic colours. Nevertheless, chromatic colours are trending at regular intervals (KBA, 2021). Due to this periodic reappearance, colour states a quiet exciting factor for design age perception. Black, white, grey and blue were selected for the conjoint analysis.

#### *2.3.5 Interfering stimuli*

In the photoshopped images, interfering stimuli were removed. These include, among others, the license plates. They were blended to prevent assumptions about the model age based on the numbering. The vehicle wheels, with their different rim designs, also pose a source of interference. Here, uniform, rotating rims were retouched into all stimulus patterns, thus preventing formal aesthetic evaluation or influence. Furthermore all images were cropped and integrated into the online study without an environment, apart from a standardized artificial shadow. Figure 3 shows an example of the original material and the derived stimulus pattern.


**Figure 3. Example of stimulus pattern (images by adac.de)**

### 2.4 Questionnaire design and distribution

An online questionnaire was created using Google Forms and consists of two parts. In the first part, the participants provide information about their age, gender, their predominant place of residence in the last 10 years and the used device for the study. In addition, the participants rate their own level of knowledge in the subject areas “car (general)”, “car brands and models”, “design (general)” and “vehicle design” based on the German school grading system from 1 (excellent) to 6 (insufficient).

The second part comprises the evaluation of the 16 stimulus patterns for the conjoint analysis. For this purpose, the participants are provided with a six-point scale ranging from "rather old" to "rather new". The presentation order of the stimulus patterns is randomized. After completion of the survey, there is also the possibility to give feedback via a text field. The design of the questionnaire was reviewed with regard to compatibility on different devices, such as computer, smartphone and tablet. As no restrictions were identified, the distribution was carried out via email distribution lists as well as WhatsApp groups.

# 3 Results

## 3.1 Sampling and demographics

A total of 205 people participated in the study. In an initial plausibility check, however, three data sets had to be removed because the entries appeared inconsistent and untrustworthy. The mean age of the remaining group (*N=202*) was 37.5 years (*SD=16.5 years*). 135 men (*66.8%*), 65 women (*32.2%*), and two diverse individuals participated. Smartphones were the most common medium for study participation (*N=149; 73.8%*), followed by computers (*N=48; 23.8%*) and tablets (*N=5; 2.5%*).
The mean values in the subjects' self-assessment were in the range of good (grade 2) to satisfactory (grade 3). There was an increasingly critical self-assessment with increasing specialization of the subject area, although the standard deviation remained roughly equal. The best performing area was general knowledge of cars (*M=2.70; SD=1.09*), followed closely by knowledge of car brands and models (*M=2.80; SD=1.17*). General design knowledge achieved third place (*M=2.95; SD=1.01*) and vehicle design knowledge (*M=3.14; SD=1.03*) finished in the last place. All curves show a left-skewed distribution.

## 3.2 Aggregated conjoint analysis

The aggregated results of the conjoint analysis are shown in table 1. The individual part-worth utilities of the levels were calculated with SPSS and reflect the influence on the design age. The evaluation of the stimulus patterns was done inverted, i.e. on the scale the extreme "rather old" was coded with 1, while the other extreme "rather new" was coded with 6. Thus, the higher the resulting value from the conjoint analysis, the newer and lower the design age. A negative part-worth utility reduces the overall score and thus increases the design age, since the vehicle is perceived as rather old. A positive part-worth utility, on the other hand, reduces the design age. The headlights attribute is a good example of this temporal effect. The chronologically oldest level, the headlight from 2009, brings a negative part-worth utility (*-0.524*), which increases the perceived design age. This senescence is already attenuated for the 2013 headlight and reverses to a small positive effect in 2017. The chronologically newest headlamp has the largest rejuvenating effect on design age, with a part-worth utility of *0.525*.
The exterior body category shows that vans increase design age the most, followed by compacts. The coupe cut favours a tapering of the design age, as does the sedan exterior.
The levels of the radiator grille show only low part-worth utilities and do not correspond to the expected chronological order. For example, the 2006 grille generates a higher design age than the 1996 level.
Only low part-worth utilities are found for the colours. Grey appears oldest, followed by black and white. Blue has the highest part-worth utility among the colours. As with the radiator grilles, however, it is clear that the values in relation to the headlights have only a small potential influence on the perceived design age.

**Table 1. Part-worth utilities for conjoint attributes (aggregated)**

| Attribute | Level | Part-worth utility | Deviation | Visualisation |
|---|---|---|---|---|
| *Exterior body* | Sharan (2011) | -0.304 | .110 | |
| | Golf VI (2009) | -0.160 | .113 | |
| | Scirocco (2009) | 0.201 | .110 | |
| | Passat B7 (2011) | 0.264 | .110 | |
| *Radiator grille* | 1996 | 0.002 | .097 | |
| | 2006 | -0.056 | .099 | |
| | 2011 | 0.055 | .092 | |
| *Headlights* | 2009 | -0.524 | .110 | |
| | 2013 | -0.022 | .110 | |
| | 2017 | 0.022 | .113 | |
| | 2020 | 0.525 | .110 | |
| *Colour* | Grey | -0.052 | .110 | |
| | Black | -0.028 | .110 | |
| | White | 0.018 | .113 | |
| | Blue | 0.062 | .110 | |
| **Constant** | | 3.724 | .065 | -0.5 -0.25 0 0.25 0.5 |

This fact shows again clearly when looking at the relative importance of the attributes of the conjoint analysis (see table 2, column "Overall"). If all attributes were equally important for the design age, the respective values would be 25%. However, the headlights claim a good 8 percentage points and the exterior body 4 percentage points more than expected, while the colour and the radiator grille are below the mark of equal distribution.

## 3.3 Cluster analysis

For a more detailed picture, it is necessary to look at the individual results of the conjoint analysis. An individual conjoint profile is calculated for each participant using SPSS. The data sets are normalized to compare the individual values with each other and to perform a cluster analysis. By means of a dendrogram, it becomes clear that the 202 data sets can be divided into three clusters. The implementation is conducted with a k-means cluster analysis. Renewed conjoint analyses are carried out for the individual clusters. Stronger tendencies and a more uneven distribution of the relative importance of the individual attributes now emerge in the results. The relative importance can be found in table 2, as can key figures for the clusters.

**Table 2. Overall results and cluster comparison for relative importance**

| | Overall | Headlight cluster | Exterior cluster | Balanced cluster |
|---|---|---|---|---|
| **N** | 202 | 75 | 59 | 68 |
| **Male / female / diverse [%]** | 66.8 / 32.2 / 1 | 81.3 / 18.7 / 0 | 59.3 / 39.0 / 1.7 | 57.4 / 41.2 / 1.5 |
| **Attribute** | **Relative importance [%]** | **Relative importance [%]** | | |
| *Exterior body* | 29.182 | 20.135 | 41.894 | 27.089 |
| *Radiator grille* | 17.358 | 15.187 | 16.431 | 20.814 |
| *Headlights* | 33.098 | 47.091 | 22.965 | 26.943 |
| *Colour* | 20.362 | 17.587 | 18.710 | 25.154 |

25%

The first cluster comprises 75 subjects (*37.1%*) and shows a clear focus on headlights. The ranking of the part-worth utilities remains the same compared to the aggregate view, but the values of the headlights increase significantly. A noteworthy feature of this cluster is the higher proportion of male subjects compared to the overall sample.
There are 59 participants (*29.2%*) in the second cluster. As with the first cluster, a shift in importance towards one attribute can be observed, although not as strong. The exterior body is determining the design age perception for the subjects in this cluster. The ranking within the part-worth utilities changes in the category colour as blue falls back and now ranks between grey and black with a negative value.
The third cluster contains 68 subjects (*33.7%*). Relative importance hovers around the 25% value for all attributes except the radiator grille, indicating a roughly equal distribution. The categories seem to be in balance. There are two clear dissimilarities in the part-worth utilities compared to the other clusters and the overall evaluation. The Scirocco slips out of position and falls to last place in its category. In addition, the headlights from 2013 (part-worth utility - *0.030*) and 2017 (part-worth utility - *0.098*) do not reflect the chronological order of their market launch. Another feature of this cluster is the significantly higher proportion of women, 41.2%, compared to the overall sample average of 32.2%.
All clusters seem to have regional dimensions. For the 199 subjects who stated their place of residence, a correlation between the first number of their postcode and their cluster group could be identified ($\chi 2(20, N=199) = 47.78;$ $p< .001$). The effect size for this finding, Cramer's $V$, was moderate ($V=.346; p<.001$).

## 4 Discussion

Our study shows that the design age of cars is influenced to varying degrees by design elements. The general trend in the aggregated conjoint analysis is also evident in the individual clusters, although individual attributes are more intensely prevalent. For special customer groups, further market research measures are recommended.
The findings can be transferred well into product development. Cars are upgraded in terms of design and technology during their product life cycle through so-called facelifts. With a limited development budget, prioritisation of design elements may be necessary. In this situation, vehicle designers can approach these decisions with the understanding of the design age perception. As for the chosen design elements, the exterior body can be excluded, as it remains the same during a facelift. By comparing the values of relative importance of the radiator and the headlights, it seems that the frequently practiced design upgrade in the headlight area is in fact much more profitable than the development of a new radiator grille. Colour has an important meaning especially for customers from the third cluster. Here, designers should offer a modern colour scheme even if the effects are marginal for other customer groups.
A limitation of our research is the selection of attributes. The calculated relative importance is only valid and meaningful within this constellation. If other design elements are added, such as the wheel rims or the rear lights, the percentages will decrease because the relative importance is distributed among more attributes. The data of this study therefore needs to be scaled before it is transferred to a real product. Another limitation of the experimental setup is the restriction to a fixed perspective representation. This setup requires a comparable spatial imagination and suitable abstraction skills in all participants.
The study also revealed a correlation between the place of residence and the cluster affiliation of the participants. We suspect that not only the attitude of the participants but also their conditioning by external stimuli influences the perception of the design age. By analysing the data from the Kraftfahrt-Bundesamt (KBA 2021), we see that the annually rate per capita of new registrations in Mecklenburg-Western Pomerania (21.4 new registrations / 1000

inhabitants), for example, is significantly lower than in Hesse (47.4 new registrations / 1000 inhabitants). If this discrepancy continues for several years, it can be assumed that the car stock will differ regionally and that vehicles of certain design ages will dominate the regional environment. This could reduce the perceived design age in municipalities with low registrations, while participants from municipalities with high registrations are already up to date by new models.

## 5 Conclusion and outlook

In this paper, the conjoint analysis is adapted to investigate factors influencing the design age. Using the example of a car, the design elements of exterior body, headlights, radiator grille and colour as well as their representations are quantified in terms of their part-worth utility and relative importance. The headlights and the exterior body in particular seem to dominate the subjective perception of the design age. A cluster analysis confirms this assumption and reveals three clusters. Participants within the headlight cluster and the exterior cluster focus on these same attributes in their temporal evaluation of the car. In a third cluster, there is a rough balance between the attributes and their relative importance.

In terms of sustainable product development and product usage, the findings can be utilised to keep the user's perception of the product within the range of an acceptable design age. Through design measures for high potential design features, obsolescence effects may be mitigated and prolonged use is encouraged. Furthermore, the aspect of regionality in the perception of design age in cars raises the question of whether the car renewal rate is not only based on economic conditions, but whether the urge for novelty could also be influenced by the buyer's environment. The scope of research should therefore be extended to other products that also cover multiple generations. Especially in consumer electronics with short renewal cycles, a robust design age of already purchased products may delay the need for replacement and thus contribute to resource preservation.

## Citations and references


Chassy, P., Lindell, T. A. E., Jones, J. A., & Paramei, G. V. (2015). A Relationship Between Visual Complexity and Aesthetic Appraisal of Car Front Images: An Eye-Tracker Study. *Perception*, 1–13. https://doi.org/10.1177/0301006615596882

Chen, L.-L., Kang, H.-C., & Hung, W.-K. (2007, November 12). *Effects of Design Features on Automobile Styling Perceptions*. IASDR 07, Hong Kong, China.

Fischer, M. S., Holder, D., & Maier, T. (2021). Are Brand Affiliation Tasks and Similarity Evaluations Comparable? An Examination Using the Example of the Vehicle Front. In C. S. Shin, G. Di Bucchianico, S. Fukuda, Y.-G. Ghim, G. Montagna, & C. Carvalho (Eds.), *Lecture Notes in Networks and Systems. Advances in Industrial Design* (Vol. 260, pp. 805–812). Springer International Publishing. https://doi.org/10.1007/978-3-030-80829-7_98

Green, P. E., Krieger, A. M., & Wind, Y. (2001). Thirty Years of Conjoint Analysis: Reflections and Prospects. *Interfaces*, *31*(3 - Supplement), 56–73. https://doi.org/10.1287/inte.31.4.56.9676

Halbey, J., Philipsen, R., Schmidt, T., & Ziefle, M. (2018). Range Makes All the Difference? Weighing up Range, Charging Time and Fast-Charging Network Density as Key Drivers for the Acceptance of Battery Electric Vehicles. In N. A. Stanton (Ed.), *Advances in Human Aspects of Transportation: Proceedings of the AHFE 2017 International Conference on Human Factors in Transportation, July 17−21, 2017, Los Angeles, California, USA* (pp. 939–950). Springer International Publishing. https://doi.org/10.1007/978-3-319-60441-1_90

Hillig, T. (2006). *Verfahrensvarianten der Conjoint-Analyse zur Prognose von Kaufentscheidungen: Eine Monte-Carlo-Simulation*. Zugl.: Berlin, Techn. Univ., Diss., 2004 (1. Aufl.). *Gabler Edition Wissenschaft*. Dt. Univ.-Verl.

Holder, D. (2016). *Gefallensurteil und Blickanalyse zum Fahrzeugdesign zukünftiger Aufbaugestalten anhand einer technischen Prognose*. Dissertation, Stuttgart, Universität Stuttgart. http://dx.doi.org/10.18419/opus-9045

Holder, D., Benz, T., & Maier, T. (2018). Semantic Influence of the Radiator Grille on Vehicle Front Design in the Course of Current EV-Design. In W. Chung & C. S. Shin (Eds.), Advances in Affective and Pleasurable Design: *Proceedings of the AHFE 2017 International Conference on Affective and Pleasurable Design*, July 17–21, 2017, Los Angeles, California, USA (pp. 53–64). Springer International Publishing. https://doi.org/10.1007/978-3-319-60495-4_6

Hyun, K. H., Lee, J.-H., Kim, M., & Cho, S. (2015). Style synthesis and analysis of car designs for style quantification based on product appearance similarities. *Advanced Engineering Informatics*, 483–494. https://doi.org/10.1016/j.aei.2015.04.001

Ikemoto, H., & Yamaoka, T. (2011). Conjoint Analysis Method That Minimizes the Number of Profile Cards. In *International Conference on Human-Computer Interaction* (pp. 23-28). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-22098-2_5

Kern, F. & Maier, T. (2020). Eine Frage der Zeit – Alterswahrnehmung in der Mensch-Produkt-Interaktion. *GfA Frühjahrskongress 2020: Digitaler Wandel, digitale Arbeit, digitaler Mensch?*. Berlin, GfA-Press, Dortmund.

Kiessling, J. M., Kern, F., Reichelt, F., Holder, D., & Maier, T. (2021). The Age of Design - How Users Perceive the Chronological Order Within Automobile Generations. *Proceedings of the Design Society*, *1*, 2981–2990. https://doi.org/10.1017/pds.2021.559

Kohler, T. C. (2003). *Wirkungen des Produktdesigns: Analyse und Messung am Beispiel Automobildesign* (Gabler edition Wissenschaft). *Forschungsgruppe Konsum und Verhalten*. Deutscher Universitätsverlag.

Kraftfahrt-Bundesamt (2021). https://www.kba.de/DE/Statistik/Fahrzeuge/Neuzulassungen/neuzulassungen_node.html

Liem, A., Abidin, S. Z., & Warell, A. (2009). Designers' perceptions of typical characteristics of form treatment in automobile styling. *DeSForM - Conference on Design and Semantics of Form and Movement*, 144–155.

Luce, R. D., & Tukey, J. W. (1964). Simultaneous conjoint measurement: A new type of fundamental measurement. *Journal of Mathematical Psychology*, *1*(1), 1–27. https://doi.org/10.1016/0022-2496(64)90015-X

Ranscombe, C., Hicks, B., & Mullineux, G. (2012). A method for exploring similarities and visual references to brand in the appearance of mature mass-market products. *Design Studies*, 33(5), 496–520. https://doi.org/10.1016/j.destud.2012.04.001

Rao, V. R. (2014). *Applied Conjoint Analysis*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-87753-0

Reid, T. N., Gonzalez, R. D., & Papalambros, P. Y. (2010). Quantification of Perceived Environmental Friendliness for Vehicle Silhouette Design. *Journal of Mechanical Design*, 132(10), 101010. https://doi.org/10.1115/1.4002290

Tumminelli, P. (2006). *Car design*. teNeues Verlag.

Windhager, S., Slice, D. E., Schaefer, K., Oberzaucher, E., Thorstensen, T., & Grammer, K. (2008). Face to Face: The Perception of Automotive Designs. *Human Nature* (Hawthorne, N.Y.), 19(4), 331–346. https://doi.org/10.1007/s12110-008-9047-z

Windhager, S., Hutzler, F., Carbon, C.-C., Oberzaucher, E., Schaefer, K., Thorstensen, T., Leder, H., & Grammer, K. (2010). Laying eyes on headlights: Eye movements suggest facial features in cars. *Collegium Antropologicum*, 34(3), 1075–1080.