Preliminary study on perceived comfort of car seats: A quantitative approach to visual cues

Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 104 (2021) 116–121

www.elsevier.com/locate/procedia

54th CIRP Conference on Manufacturing Systems

Preliminary study on perceived comfort of car seats: A quantitative approach to visual cues

Bastian Quattelbaum[a,*], Kostas Stylidis[b], Alina Braun[c], Rikard Söderberg[b]

[a]Hochschule Niederrhein, Faculty Textile and Clothing Technology, D-41065, Mönchengladbach, Germany
[b]Chalmers University of Technology, Department of Industrial and Materials Science, SE-412 96, Göteborg, Sweden
[c]Geely Design Global, Valdemar Noréns Gata 3, 417 55, Göteborg, Sweden

*Corresponding author. +49-21-611-863-953; E-mail address: bastian.quattelbaum@hs-niederrhein.de

Abstract

The automotive industry is transitioning towards a more digital future - not just the digitalization of the product itself but also the process of customer interaction, such as during the product selection process. In the product selection process, companies are enabled to collect and analyze large amounts of customer and usage data but are also challenged to understand the gathered digital data. In designing physical components, analyzing, and understanding such data can provide a competitive advantage. In gaining deeper insight into the digital selection process of cars and for understanding customers preferences related to perceived comfort of car seats, we applied a visual appearance study by presenting digital information of physical components.

Keywords: Perceived Comfort, Car Seats, Visual Appearance, Best-Worst-Scaling

1. Introduction

Due to the impact of COVID-19 motor shows were canceled and/or postponed worldwide and car retailers were closed in many countries for several months. When wanting to buy a new car, customers faced challenges by not being able to physically interact with their desired car by visiting motor shows or physical retailers. With no physical interaction possible, next to performance attributes as well as price, customers' purchase decision heavily relied on visual attributes of the car. Indeed, customers had to rely on online retailing choosing their car based on a set of visuals such as images and videos. Even before the pandemic, functionality and performance attributes of cars were often taken for granted, shifting consumers' attention to the aesthetics. Previous studies showed visual appearance of products has often been the main factor impacting consumers' purchasing behavior. Also, the visual appearance of car seat has been shown to affect customers' purchase decisions [1-3].

These studies have identified perceived comfort of a car seat as one very important factor impacting consumers' choices [3]. However, with no actual physical interaction, how do customers judge the comfort of a car seat? Can customers judge if a car seat is less or more comfortable only by looking at it? How do different car seat attributes impact perceptions of car seat comfort? For example, is a wide designed seat perceived to be more comfortable? Is a car seat with less stitching and seam lines perceived to be more comfortable than a seat with many seam lines and heavy stitching? How about the selected material? Can colors impact perceptions of comfort? These are important questions to answer allowing car designers and engineers to better understand customers' perceptions to meet their expectations.

Research on customers' perceptions of car seat comfort is limited, such that we were unable to answer the above questions prior to this study based on previous findings. This research aimed to answer the above questions by testing which car seat attributes impact customers' perceptions of car seat comfort and to what extent. In this study we reflect on visual

10.1016/j.procir.2021.11.020

appearance of the driver seats for entry segment car market vehicles, such as Opel Corsa, Renault Clio, Toyota Aygo, Fiat 500, and Ford Fiesta. To fulfill objectives of the study we implemented a quantitative survey with 53 respondents. These respondents were given online tasks to rank the appearance and comfort of the car seats. One of the methods used in the surveys was Best-Worst Scaling (BWS), which is a quantitative choice-based technique used for understanding a respondent's or a respondent group's relative valuation of different products or product attributes [4]. We used BWS along with semantic-differential scale questions, which helped to detect lack of discrimination and confounding among respondents. Analysis of the results allowed to understand which 'ingredients' of a car seat design play the most significant role in customers' appreciation.

The aim of this study is not to model seat comfort or assign a relative comfort ranking, but to implement a quantitative approach into trade-offs among factors impacting decision making and concerns regarding a car seat design from a customer's viewpoint.

This paper is structured as follows: Section 2 introduces the context and background of this study. Section 3 describes the methodology applied in this study. Section 4 presents the data analysis and discusses the results. Section 5 offers conclusions.

2. Background

2.1. Car Seat Comfort – Ergonomics vs Aesthetics

People like comfortable seats [5]. The car seat comfort is one of the main enablers for the customer's purchasing decisions in any car market segment. However, a majority of studies are focused on ergonomics and biomechanics with the aim to reduce actual discomfort of the car seats [6-9] instead of focusing on the car seat design itself. Only few studies deal with the perceived comfort and appearance of car seats primarily due to the complexity of the task, we assume. The perceived comfort of the car seat can be significantly different from the actual seat comfort. Indeed, the 'first look' and/or first 'perceived feel' are multifaceted events that might be not exclusively related to the seat itself but to the context, such as the environment the car is shown, or the mental model based solely on customer's expectations or memory. Erol et.al. [10] showed in their work how car seat appearance influences perceived comfort and that visual appearance of car seats triggers the emotional response and significantly affects the perception of comfort. This just supports the earlier findings from Helander [1] focusing on the ergonomics of chairs. This particular study verified that "users could distinguish between parameters that relate to aesthetics and comfort but had difficulty in distinguishing between ergonomics features." Indeed, aesthetics and visual cues can play more significant role for the perceived comfort than it may have believed before. Kang et.al. [11] performed a study quantitively evaluating the influence of a car seat appearance and comfort on consumers' willingness to pay. They conducted an experiment measuring this tradeoff using hierarchical Bayesian conjoint analysis combined with the in-person evaluation of a real car seat. Findings of this study suggests that car seat preferences are heterogeneous according to brand segmentations (i.e., entry, premium or luxury car market segment). It was also determined that the aesthetic appearance of car seats is as important as the ergonomic comfort rating, and luxury customers care about seat appearance and comfort.

Studies on car seat comfort explore car seat design in isolation from external factors [10]. At this point, authors tend to follow an evaluation approach on perceived comfort in the context of the specific car design, considering interior and daylight opening (DLO) visible parts and influencing factors. The study performed by Naddeo et.al. [12] demonstrated that the highest comfort appreciation was obtained when customers evaluated the seat inside the car. Therefore, we believe that this study will contribute to the holistic understanding of car seats' perceived comfort quantifying customer's perception.

2.2. Car seat materials

We also acknowledge that materials may have a strong impact on the comfort of a car seat. Common materials used are leather, artificial leather, and textiles. There are several criteria available for the development of car interior materials: tensile strength, abrasion and pill resistance, air permeability, compression resistance, elasticity, light fastness at high temperatures, stiffness, ease of cleaning, etc.; as well as processing requirements like mouldability, susceptibility to compression, sewability [13,14]. Another comfort indicator may be the breathability of materials. The soft material finishing is one contributor to the breathability of the material and can affect the comfort of the car seat and may depend on environmental conditions. Materials are one important factor of the whole seat aesthetics and can affect the perception of comfort [15,16]. Thus, the impact of materials on perceived seat comfort is under investigation (e.g. as visual cues).

As mentioned before leather, artificial leather, and textiles are the most common materials used in a car interior and specifically the most common used materials for car seats. For the future it has to been taken into consideration that customers and regulations are aiming for more sustainable materials [17]. Taking textiles as an example, today almost 90% of textile fibers used in car seats are polyester. The use of recyclable bio-composite structures and materials such as flax, hemp, kenaf, and sisal for structural components, panels and seats are future options. [13,18]. The impact of these materials on perceived comfort needs to be evaluated. In this study we gathered customers' feedback on eco-friendly materials and general contribution of materials appearance to the overall comfort perception.

3. Methodology

We introduced the research methodology as illustrated in Fig. 1 and designed a web-based survey with a set of semantic-differential questions to understand whether certain variances were deemed important for the respondents.

These questions were needed to anchor the ordinal rankings found next in the BWS section, which revealed whether one car seat is perceived to have higher comfort than another. First, we compiled a series of selected car seat images provided by the

A2Mac1 Automotive Benchmarking database [19]. We selected similar color schemes and car body color. Any visible car brand affiliations were removed to avoid any possible bias related to the brand name. In this study we reflect on visual appearance of the driver seats for entry car market segment vehicles. Thus, the following cars were chosen Opel Corsa, Renault Clio, Toyota Aygo, Fiat 500, Ford Fiesta. We also included a mid-size SUV, Geely Haoyue, which obviously falls out of the chosen market segment. The reason for this selection was to improve reliability of the results. This vehicle has a higher standard related to the seats' execution and craftsmanship. We were expecting that potential customers should be able to identify the difference in perceived comfort and overall quality.

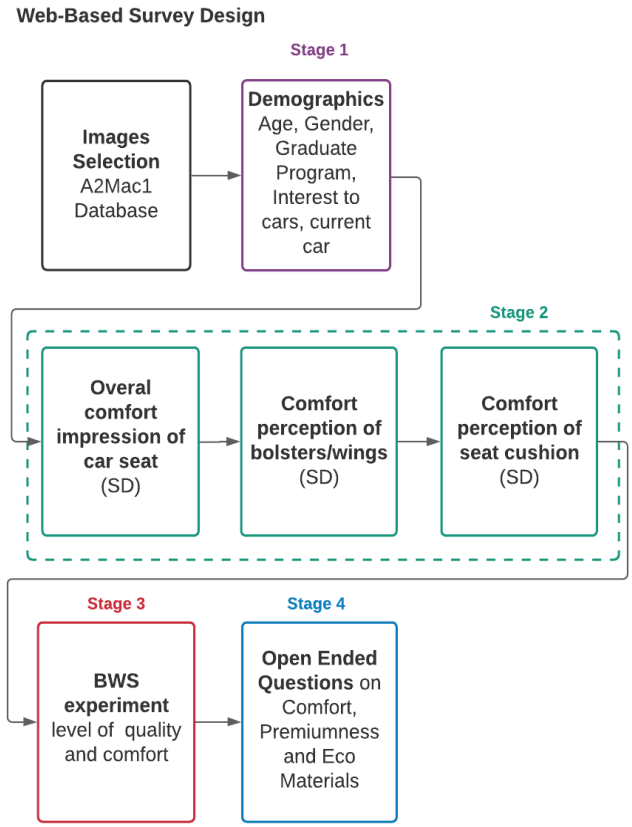

Fig. 1: The research methodology applied and online web-based survey.

The car seat's viewpoint was chosen to simulate a real show-room experience when a customer approaches the car for the first time. The view included the interior and DLO, as shown in Fig. 2. When displaying questions regarding the specific car seat parts (e.g., bolsters or seat cushions), the rest of the visible interior was blurred not to distract respondents (see Fig. 3). The web-based survey started with the questions screening demographics, continued evaluating the six car seat bolsters/wings' comfort impressions, followed by questions regarding six car seat cushions' perceived comfort. Finally, the BWS experiment and the choice tasks were presented to the respondents with different permutations of the six items (overall seat comfort).

The permutations and numbers of questions were automated using the Sawtooth Discover online survey software module. In each task, participants (N=53) have been asked to select the "*lowest comfort level*" and "*highest comfort level*" of displayed car seats images.

Fig. 2: The view of a car seat presented for overall perceived comfort evaluation.

Fig. 3: The view of a car seat cushion presented for the perceived comfort evaluation with the blurred interior parts.

Finally, several multiple choice and open-ended questions were asked to grasp respondents' attitudes to eco-materials, 'premium look', and factors impacting car seat comfort. The average completion time was approximately 20 minutes. Survey design and results were subjected to data analysis using Discover Survey Software [20].

4. Results and Discussion

The online study was completely executed by 53 respondents located in Germany ranging from 18 to +50 years with an arithmetic mean of 24.81 years. (Fig. 4).

As the scope of the study was cars within the entry segment the shown age distribution is classed as representative. The gender composition of the study was male dominant with 39 male respondents compared to 12 female and 2 others. In addition to these demographical attributes the participants were asked to classify themselves as car enthusiasts or not. 50% classified themselves as car enthusiast while 43% said they intend to use a car as a tool to travel from A to B and 7% said

they do not belong to one of these groups. In general, the attitude towards the car topic is balanced between participants who are highly interested and participants who see it as a commodity. Therefore, the results represent a good distribution of general car users.

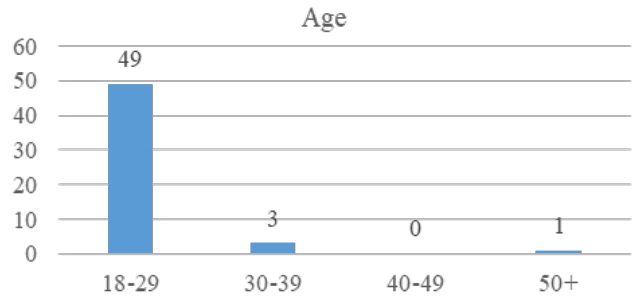

Fig. 4: Demographical composition - Age

Beside their attitude the participants were asked which factors contribute most to the comfort experience overall. They were given the following preselected items: ‘Overall seat width’, ‘overall seat height’, ‘height of the side bolsters’, ‘options to adjust car seat’, ‘color’, ‘stitching’ or ‘others’. Predictably the item ‘options to adjust the car seat’ which allows a set-up of the seat to the specific personal requirements was mentioned most often (42 %) illustrated in Table 1. Subsequently the dimensional items of the seat were named with ‘overall seat width’ and ‘height of the side bolsters’ of high contribution.

Table 1. Comfort contribution.

Item	*Absolute frequency*	*Relative frequency*
Overall seat width	11	20 %
Overall seat height	4	7 %
Height of the side bolsters	12	23 %
Options to adjust car seat	22	42 %
Color	2	4 %
Stitching	2	4 %
Others	0	0 %

Fig. 5 illustrates the factors which the respondents have rated as important for the premium experience of a car seat. The most prominent item is ‘material type and combinations’. With a notable gap the items ‘Seat appearance in general’ and ‘Seat features’ were named.

Based on these underlying thought models the participants did answer the questions regarding the comfort perception of the seat bolsters and the seat cushion for the selected six car models. Applying a Likert scale from 1 to 6, with 1 corresponding to lowest comfort and 6 to the highest comfort, the visual car seat appearance of the Renault and Toyota model did achieve the highest average ratings and the Ford model the lowest. (Fig. 6)

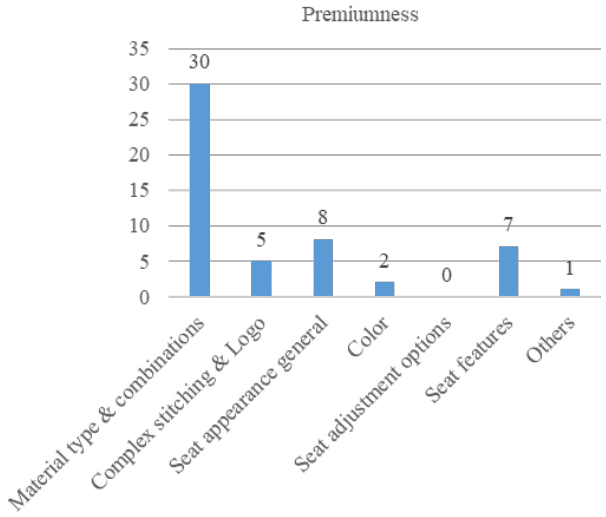

Fig. 5: Factors for premium experience

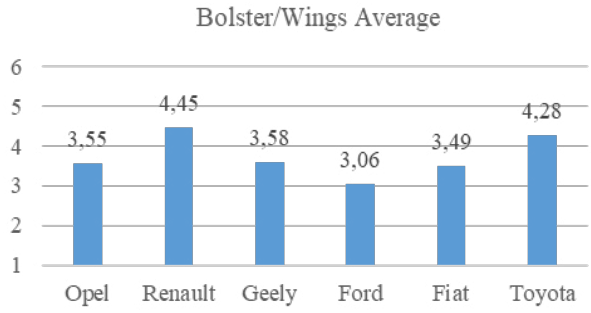

Fig. 6: Average of seat bolster/wings comfort ratings

Fig. 7 shows that the given Likert scale was fully applied for the presented car models with a tendency not to use the margin values. A preliminary analysis of the relationship of the different judgements show that there is strong connection for example between the low perception of the Ford bolster comfort and the high perception of Toyota with a p-value of p=0.072. Additionally, the data shows that 60% of the respondents who named the dimensional items as comfort contributors classified Renault applying the Likert scale with 5 or 6.

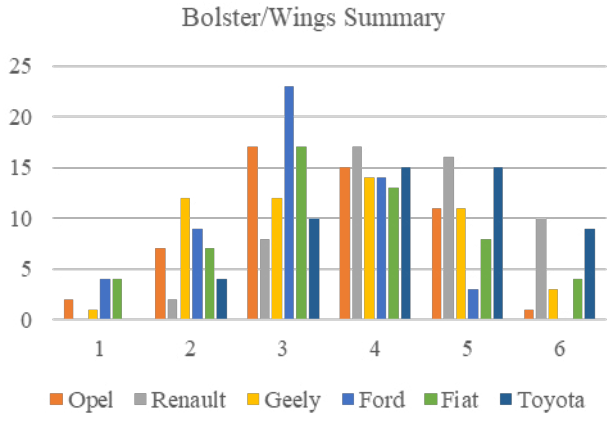

Fig. 7: Absolute frequencies for comfort of seat bolsters/wings

Analogous to the seat bolster comfort experience Fig. 8 and Fig. 9 show the comfort experience for the seat cushion imagining a several hour journey. This time the model of Renault and Geely got the highest ratings and Ford again the lowest. Compared to the bolsters the seat cushion gets overall lower scorings. In this case 41% of the respondents applied a 5 or 6 on the Likert scale and 60% >4, who named the dimensional items as comfort contributors. The preliminary regression analysis also shows a strong relationship between the Ford and the Geely judgment (p = 0.001).

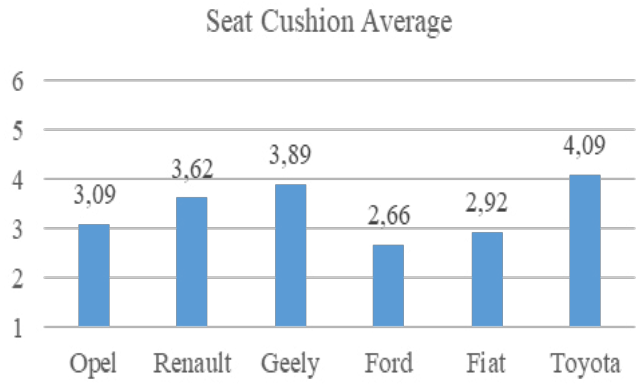

Fig. 8: Average of seat cushion comfort ratings

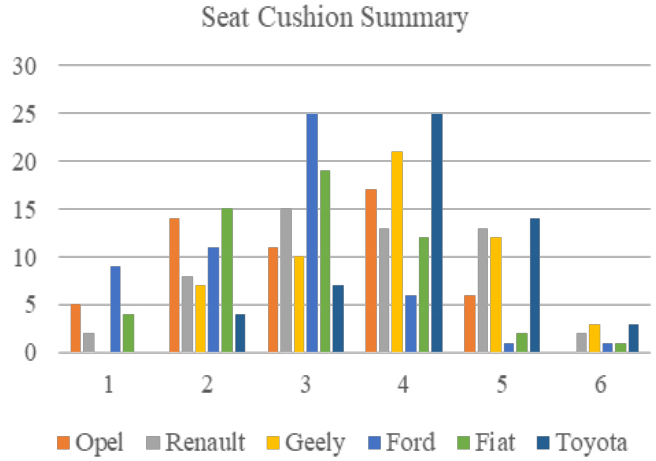

Fig. 9: Absolute frequencies for comfort of seat cushion

After assessing the seat comfort in detail with focus on the seat cushion and the bolster/wings the participants performed the BWS exercise comparing the entire seat appearance of the different car models.

Notably and likewise for the detail comfort appearance the car models of Geely, Toyota, and Renault were related with the highest comfort perception. The BWS results can be separated into three sections: (1) Geely, Toyota, Renault – mean perception score below 7; (2) Opel – mean perception score around 20; (3) Ford, Fiat – mean perception score above 30. (Table 2 and Fig. 10)

For a further meaningful interpretation of the extracted results the authors classified the chosen seats with regards to the items of the comfort contribution already presented in Table 1. The authors performed a qualitative assessment using a scale from 1 (narrow, low, few, etc.) to 6 (wide, high, many, etc.) and used the following assignment: #1 Opel, #2 Renault, #3 Geely, #4 Ford. #5 Fiat, #6 Toyota.

Table 2. BWS ranking comfort perception.

Model	*Mean perception score*	*Lower 95% confidence interval*	*Upper 95% confidence interval*
Geely	5.19	3.83	6.55
Renault	5.95	4.04	7.86
Toyota	6.90	5.02	7.28
Opel	19.43	17.04	21.83
Fiat	30.71	28.19	33.24
Ford	31.82	29.77	33.87

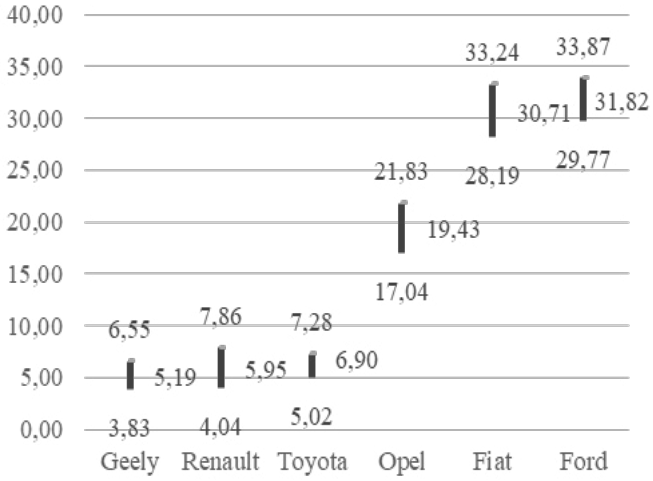

Fig. 10: BWS ranking comfort perception

Table 3. Seat classification regarding comfort contribution items

Items	#1	#2	#3	#4	#5	#6
Overall seat width	2	5	4	3	4	4
Overall seat height	4	4	5	3	3	5
Height of the side bolsters - backrest	3	5	5	3	5	5
Height of the side bolsters – seat	4	4	4	2	3	4
Color	2	3	2	1	2	3
Stitching	3	2	3	4	5	3

The item ‘Options to adjust car seat’ was left out purposely as this is difficult to assess by just a visual representation via a picture. The bolster height was separated to the bolster height of the backrest and the seat cushion. As shown the chosen seats represent a wide range of coverage of the different items. (Table 3).

If we take the items “Overall seat width” and “Height of the side bolsters” into a closer consideration – due to the fact they were rated with the highest comfort contribution impact (Table 1) – the classification of the seats shows that Geely, Toyota, and Renault are classified on the higher margins of the scale and are ranked as most comfortable in the BWS study. Oppositely Fiat and Ford are classified on the lower margins and are also ranked BWS-wise as lowest comfortable.

5. Conclusion and Outlook

Summarizing the outcomes of this preliminary study it is shown that the comfort of a cars’ driver seat can be judged by visual cues only. The results are highly valuable indicating that only by looking at car seats consumers can make judgments on car seat comfort. This finding is unique showing that comfort judgements, which are usually thought to be made only after physical contact, can be made at an earlier visual interaction stage. This insight offers car designers and engineers the knowledge in how to design and engineer car seats impacting perceptions of comfort. This study on visual appearance of the seats showed that the customer perception on comfort attributes is differentiable. Different comfort contributors have impact on the comfort perception. These contributors are scalable and can be specifically impacted by the design departments.

This preliminary study was based on pre-selected items. But in an open-ended questions section the participants were asked ‘What makes the seat look comfortable?’. 25 out of the 53 respondents mentioned the selected material. Within the study material was allocated to the premium appearance and not to the comfort. Therefore – after backing up these results – a detailed study design needs to be developed to investigate the impact of material on the visual comfort appearance. The respondents mentioned focus points already: Beside the material selection itself attributes like ‘stiffness’, ‘strong wrapping’, ‘softness’, ‘wear-resistant’ or ‘breathable’ were named. As sustainability is becoming more relevant in material design nowadays, in another open-question section the participants were asked for ‘attributes for eco-friendly materials’. The respondents answered quite vague, e.g. ‘low carbon-footprint, recyclable or bio-degradable’, ‘fair-trade, vegan’, ‘natural materials’ or ‘durable’. A big challenge will be to include these attributes in visual cues.

References

[1] Helander MG. Forget about ergonomics in chair design? Focus on aesthetics and comfort!. Ergonomics. 2003.46(13-14):1306-19.

[2] Kolich M. A conceptual framework proposed to formalize the scientific investigation of automobile seat comfort. Applied Ergonomics. 2008.39(1):15-27.

[3] Kyung G, Nussbaum MA, Babski-Reeves K. Driver sitting comfort and discomfort (part I): Use of subjective ratings in discriminating car seats and correspondence among ratings. International Journal of Industrial Ergonomics. 2008. 38(5-6):516-25.

[4] Marley AA, Louviere JJ. Some probabilistic models of best, worst, and best–worst choices. Journal of mathematical psychology. 2005 Dec 1;49(6):464-80.

[5] Vink P, Bazley C, Kamp I, Blok M. Possibilities to improve the aircraft interior comfort experience. Applied ergonomics. 2012. 43(2):354-9.

[6] Reed MP, Manary MA, Flannagan CA, Schneider LW. Effects of vehicle interior geometry and anthropometric variables on automobile driving posture. Human Factors. 2000. 42(4):541-52.

[7] Sember JA. The biomechanical relationship of seat design to the human anatomy. Hard Facts About Soft Machines: The Ergonomics of Seating. Taylor and Francis, London. 1994. 221-9.

[8] Hiemstra-van Mastrigt S, Kamp I, Van Veen SA, Vink P, Bosch T. The influence of active seating on car passengers' perceived comfort and activity levels. Applied ergonomics. 2015. 47:211-9.

[9] Hiemstra-van Mastrigt S, Groenesteijn L, Vink P, Kuijt-Evers LF. Predicting passenger seat comfort and discomfort on the basis of human, context and seat characteristics: a literature review. Ergonomics. 2017. 60(7):889-911.

[10] Erol T, Diels C, Shippen J, Richards D, Johnson C. How does car seat appearance influence perceived comfort. 10th International Conference on Design and Emotion – Celebration and Contemplation; 2016. Proceedings - D and E.

[11] Kang N, Burnap A, Kim KH, Reed MP, Papalambros PY. Influence of automobile seat form and comfort rating on willingness-to-pay. International Journal of Vehicle Design. 2017;75(1-4):75-90.

[12] Naddeo A, Califano R, Cappetti N, Vallone M. The effect of external and environmental factors on perceived comfort: the car-seat experience. Proceedings of the Human Factors and Ergonomics Society Europe. 2015:291-308.

[13] Singha K. Strategies for in Automobile: Strategies for using Automotive Textiles-manufacturing Techniques and Applications. Journal of Safety Engineering, 2012, 1 (1), 7-16

[14] Grujicic, M. & Pandurangan, B. & Arakere, Guruprasad & Bell, W.C. & He, T. & Xie, Xiaoxuan. Seat-cushion and soft-tissue material modeling and a finite element investigation of the seating comfort for passenger-vehicle occupants. Materials & Design. 2009. 30. 4273-4285.

[15] Fazlollahtabar H. A subjective framework for seat comfort based on a heuristic multi criteria decision making technique and anthropometry. Appl Ergon. 2010 Dec; 42(1):16-28

[16] Silva, L, Bortolotti, S, Campos, I, Merino, E. Comfort model for automobile seat. 2012. Work. 41. 295-302.

[17] Commission Directive Directive 2000/53/EC (ELV) of tge European Parliament and of the Council

[18] W. Olle, D. Plorin. The interior of the future. Opportunities for the automotive supply industry in Thuringia. Study by Chemnitz Automotive Institute (CATI), 2019

[19] A2Mac1 Automotive Benchmarking [Computer program]. Available at https://portal.a2mac1.com (Accessed 15 January 2021)

[20] Sawtooth Software [Computer program]. Available at https://www.sawtoothsoftware.com (Accessed 15 January 2021)