The Visual Categorization of Production Automotive Seats on Descriptors of Comfort by End Users

Tugra EROL[a*], Cyriel DIELS[b], James SHIPPEN[a], Dale RICHARDS[c]

[a] Institute for Future Transport and Cities -NTDC, Coventry University – Coventry, United Kingdom CV1 5FB

[b] Intelligent Mobility Design Centre (IMDC), Royal College of Art 4 Hester Road, London,,UK SW11 4AN

[c] Department of Engineering, School of Science and Technology , Nottingham Trent University Clifton Lane, Clifton, Nottingham, NG11 8NS

* Corresponding author. Tel.: +44(0)-247-765-9320. E-mail address: erolt@uni.coventry.ac.uk

Abstract

BACKGROUND: The role of appearance of automotive seats on perceived comfort and comfort expectancy has been acknowledged in previous automotive seat research however it has not been investigated in depth.

OBJECTIVE: To explore the effects of the appearance of production automotive seats, based on the hypothesis that visual design differentiations are affective in creating comfort expectations. Identifying variables such as *Sporty*, *Luxurious* and *Comfortable* (1) pertaining to the expected comfort which are in return associated to physical attributes is of interest.

METHOD 38 automotive seat images from a manufacturer's (OEM) website and an image-based card sorting app was utilized to conduct the study with 24 participants. The resulting data was analyzed with hierarchical clustering analysis (HCA) and non-parametric tests.

RESULTS The results indicated that the perceived *Sporty*, *Luxurious* and *Comfortable* were significant descriptor items in visually differentiating the seats with certain design attributes.

CONCLUSIONS It was concluded that for *Sporty* perception, two major clusters formed where the design stimuli displayed a "discontinuity" for the seats having integrated triangular headrests forming angular shapes. On the other hand *Comfortable* perception was more readily associated with separate headrest design and rounded seat back/cushion shapes.

Keywords: Automotive, Seat, Comfort Experience, Visual impression, Attribute mapping

1 Introduction

The seat is the largest significant point of interaction with any vehicle (2), which plays an important role in the overall impression and appeal of that particular vehicle (3).Automotive seat comfort and light weighting is also becoming a key topic for all car manufacturers when designing upcoming models (4). In this respect, providing optimal comfort attributes if not superior ones that support both the psychological and physiological comfort experience as a whole is the utmost goal of the new seat designs. The concept of automotive seat comfort is regarded a highly subjective and multi-faceted phenomenon where comfort assessment is generally held with different tools and scales with increasing effort to quantify the feelings and impressions associated with the whole experience. The comfort literature adopted approaches to quantify the comfort perception and expanded on various models describing the underlying factors and mechanisms that exists for seating comfort (5,6). A recent model by Vink and Hallbeck (7) specifically defines and denotes different underlying mechanisms leading to outcomes of discomfort or comfort or both in relation to various conducted studies in literature. Van Veen & Vink (8) extended this comfort model for additional tactile and sensory experiences as a pre-condition that influence comfort expectations of the user regarding the automotive seats. It was deduced that physical interaction with a different product will influence the evaluation of an automotive seat in terms of the sensation of tactility properties. However as the study was conducted with draped seats, the visual properties and how it affected the expectations were not investigated.

Erol (9) conducted a study to identify and analyze how the "holistic automotive seat comfort experience" was constructed retrospectively by the consumers. The results revealed three major dimensions: *Visual Impression & Aesthetical Appearance Design, Safety & Design Functionality and Feelings & Well-being.* In relation to the product design literature, these dimensions were consistent with think-feel type of products where Creusen argued that "think" and "feel" dimensions regarding the information processing of products were independent of each other (10). The "think dimension" relied on functional properties and "feel dimension" on emotions and self-expression attributes. In contrast to theorized comfort model for automotive seats by da Silva et al. (11) which had 5 facets where both comfort and discomfort descriptors were deduced from studies in literature, the card sorting enabled end users category label their comfort experiences directly associating to the cluster of comfort descriptors. Focusing on the aesthetical appearance design, the descriptors and the categorizations reflected certain physical features of automotive car seat as design cues. The product appearance

roles (6) formed the basis of the rationale for the descriptors. Moreover, luxury, plush, sleek, elegant, sporty and other various descriptors (attributes) were found to play a vital role in the holistic perception of perceived comfort in automotive seats which were classified under the visual impressions dimension.

Pinkelman (1) hypothesized a consumer utility model of "comfort characteristics for automotive seats", where he argued that comfort/discomfort, sporty and luxurious were the three key variables to characterize any car seat for "comfort characteristics". The hypothetical assumptions relied on J.D. Power and Associates APEAL survey data where the study falls short of verifying the proposed variables with empirical data. Kamp (10) utilized the assessment items were comfortable, protected, relaxed, sporty and luxurious for three automotive seats adopted from a prior study by Zenk et al. (1) in order to assess the significance of relationships of seats' physical features(e.g. width, steepness of side wings, contour etc.). It was reported that the seat designs were significantly differentiated on luxurious and sporty feelings where the variable comfortable was not found to be significant. This led to the conclusion that only sporty and luxurious seat have specific design characteristics that are recognizable by the participants when the seats were covered (10). Moreover as reported by Vink et al. (4) when participants were asked to indicate the seat they would like to have in their own car , the soft seat with prominent wings was deemed more luxurious & protected which also received higher average rating compared to the flat + hard and the curved + hard seat. One major limitation of the study was that the relationships between the significant variables and how it affected comfort were not investigated whereby the seats were also not subjected to visual assessment regarding the variables. However, these findings can be partially supported by the fact that in the Erol (3) study "Luxurious" and "Sporty" variables were also observed where they were mostly used by male participants for describing the visual attributes of comfort of automotive seats. In order to investigate and to identify the visual features (the tangible elements) that prompt these experiences, a number (or a family) of production seat designs are necessary with incremental variances in the designs (12) . Moreover the selection of the particular variables (or dimensions) that the products evaluated are crucial for extracting the value of the particular attributes.

Therefore the aim of this study is twofold;

1) To explore the effects of the appearance of automotive seats on expected comfort based on the hypothesis that design differentiations lead to a taxonomy of perceptual attributes assessed. This in return is expected to provide an understanding which attributes are affective in creating comfort expectations. The pre-

determined variables of assessment for automotive seats were identified from literature and from the visual impression descriptors as *Sporty*, *Luxurious* and *Comfortable* (1,3,13).

2) To enhance the understanding if the proposed comfort characteristics variables of "automotive seats" are truly determinants in relation to the visual design of the seats. Moreover the particular relationships between the three proposed variables are of interest.

2 Materials and methods

2.1. Experimental design and Stimuli

An extensive family of automotive seat pictures have been adopted from the AUDI AG (14) website for every model on offer, with approval of AUDI AG Medienzentrale. The rationale behind the selection was the amount of variance in seat shapes within the family of seats for every car segment of the AUDI range provided a good source for the relative assessment in scope of this study, from SUV to passenger car seats i.e. A1, A3, A4, A5, A6, A7, A8, Q3, Q5, Q7, TT, R8. For each of the car segments AUDI offers a "normal" (alternatively referred to as standard) seat, a "comfort" seat and a "sport" seat type, where for certain sports car segments "shell" seats (or alternatively bucket seats) are also offered. These seat renderings are available as 3D renderings of the designs in monochrome colors (see Figure 1). For this study the 38 monochrome car seat pictures for sorting was utilized from the manufacturers site (See appendix figure A.2.), which were all commercially available real physical seats on the market at the time.

Figure 1. Four of the 38 AUDI seat designs for performance cars, "Sport" to "Shell/Bucket seat" types offered on the AUDI AG website in 2016.

The 38 seat design utilized in this study had consistent features and functional parts throughout the sample of production automotive seats (i.e. trenches, tie-down lines, seat inserts, seat back and seat cushion side bolsters) and were in accordance with the generic automotive seat designs as depicted in SAE Standard J2732 2008 "Motor Vehicle Seat Dimensions Standard" (15) (see appendix figure A.1.).

2.1.1 Participants

A sample of 24 people (equal gender split, mean age = 35,5, min=20, max=59, SD=11.4) partook in the study and were all university students and staff. Participants had at least 3 years driving experience.

2.1.2. Data collection app

The participants were asked to utilize an image-based card sorting app for iPad "qCard Sorting" (16) , where they distributed and rated the set of seat images in to 9 groups e.g. least sporty: = 1 to most sporty: =9. The first sort allows the distribution in to 3 major groups then it is followed by a sort in to 9-groups where methodology was inspired by divide-and-conquer sorting algorithm (see figure 2) (17) .The seat designs were displayed in identical dimensions on the iPad app.

Figure 2. Typical subsequent scroll screenshots of the iPad app for sorting phase (on the left) final phase after sorting and fine tuning between categories (on the right).

2.2. Protocol

Each of the three variables is entered on the semantic scale each time on the iPad app for every sorting task in a randomized manner. This was a within-subject design where all the participants were instructed to sort the images for all the variables in to the categories acting as scales from 1-9 and be mindful that it is also a rating sort (see figure 2). The application finally allowed the participants to see the rating at the end of each sort by scrolling on the whole range where it enabled a final review and fine tune on sorting results. The participants on purpose were not informed of the particular brand and real life size of the seats. There was no limitation on sorting time. Following the sorting task, a post-trial interview was conducted to obtain participants qualitative comments regarding the seat designs and the sorting task.

2.3. Analysis

The data has been analyzed with standard non-parametric tests and Hierarchical Clustering Analysis (HCA) which forms clusters of seats with respect to the rating scales used in the study (18). The HCA used "average linkage" algorithm which tends to produce clusters based on measured characteristics with rather low within-cluster variance (19).The resulting "dendogram" produces a tree of hierarchy, where the shorter

linkage distance (the lines in terms of distance displayed) from the origin indicate the similarity of the objects. Following the clustering, the mean rating values for each individual seat design on the descriptors e.g. *Sporty* vs *Luxurious*, was utilized to display the design differentiation effect of the 38 seat images utilized based on attributes (18).

3. Results

3.1 Analysis for individual car seat designs

The mean values with regards to the three variables provide an insight of the effect of the particular attributes and their effects on the perception for each seat design. In this study, the seat image sizes were kept constant, in order to provide a cross examination of all the seat designs used.

The *Sporty* rating mean values by the participants' displayed the lowest standard deviations, which indicate that the 24 participant's perceptions were more homogenous on this variable. The distribution of the C*omfort-able* and *Luxurious* variables displayed a larger spread with higher SD in the ratings indicating that there were higher variances in the categorization process.

The bucket/shell type seats had the highest *Sporty* mean ratings where the *R8 Shell seat* had the highest rating (mean=8.46, SD=1.67). The *A3 Normal (alternatively referred to as standard) seat* had the lowest rating (mean=2.17, SD=1.5) (see figure 3).

Figure 3. *R8 shell seat* (on the left hand side) had the highest *Sporty* mean rating. The *A3 Normal seat* was the lowest mean rating (in the middle) and closely followed by the *A8 Normal seat* (the right hand side)

The overall rating for seats for the *Comfortable* sort having the highest comfort mean rating was *A4 Sport seat* had the highest ratings (mean=6.54, SD=2.14). The *Q5 Normal seat* had the lowest ratings (mean= 3.13, SD=1.8) (see figure 4).

Figure 4. *A4 Sport seat* had the highest *Comfortable* mean rating (on the left hand side). The *Q5 Normal seat* has the lowest mean rating (on the right hand side)

For the overall mean ratings in the *Luxurious* dimension, having the highest luxurious mean rating was *A8 Sport seat* (mean=6.50, SD=2.4) where The *Q5 Normal seat* was the lowest (mean=2.96, SD=2.2)(see figure 5).

Figure 5. *A8 Sport seat* has the highest *Luxurious* mean rating (on the left hand side). The *Q5 Normal seat* has the lowest *Luxurious* mean rating (on the right hand side)

Non parametric tests were used for the statistical analysis. Friedman (two way) tests were significant across the 38 seat designs on all the three variables. For *Sporty* ($\chi 2$=630.6, N=24, df =37, p< .001), the pairwise comparisons yielded significant differences. The 14 sport category seats were found significantly sportier than *A8 Normal seat* and *Q5 Comfort seat*. Moreover the *A7 S Sport seat, A8 Sport seat, A1 Sport seat, TT Sport seat, R8 Sport seat, A3 Sport seat* were also found significantly more *Sporty* than *Q5 Normal seat*; see appendix for each design (p< .05,Bonferroni correction applied). For *Comfortable* ($\chi 2$=131.9, N=24, df =37, p< .001) pairwise comparison tests yielded that *A7 Comfort seat, A8 Sport seat, A6 Comfort seat, A5 S Comfort seat, A5 Sport seat and A4 Sport seat* were significantly found more *Comfortable* than *Q5 Comfort seat and Q5 Normal seat* (p< .05,Bonferroni correction applied). For *Luxurious* ($\chi 2$=155.5, N=24, df =37, p< .001) *Q5 Normal and A6 Normal seat* were found significantly less *Luxurious* than 6 type of seats; *A5 S Sport seat, A5 S Comfort seat A6 S Sport seat, A7 S Sport seat, TT S Sport seat, A8 Sport seat, A3 S Sport seat*; see appendix for each design (p< .05, Bonferroni correction applied).

3.2 Hierarchical Cluster Analysis (HCA)

The aim of HCA is to link more and more objects together and *amalgamate* larger clusters of increasingly dissimilar elements. The dendogram tree structures generated by the HCA procedure in figure 6, display the particular grouping of the seat designs. At the cut off distance of 10, the distinct two separate groups in *Sporty* can be observed. Amongst the three variables, *Sporty* variable can be attributed as the most coherent within subjects in terms of the distance generated. The categorization effects are concurrent within the participants with respect to the mean values and SD values of the sportiness ratings (see Figure 6). The particular group of seats which from the upper cluster group 1(**box 1**) of *Sporty* including the shell seat type have the highest sportiness mean rating of *R8 Shell seat* (mean=8.46, SD=1.67) where the lowest is of the *TT Sport* seat with a

mean value of 6.87 (SD=1.42). These formed typically the sport seats typology of design characteristics. Cluster group 1 for the lowest ***Sporty*** perception encompasses the *A8 Sport seat* (mean= 5.13, SD=2.07) which has the only separate headrest in the 14 sport seats within the group. The bottom larger cluster **box 2** for the ***Sporty*** dendogram, the box includes the *A3 Normal seat* (see figure 3) as the lowest for sportiness with a mean value of 2.17 (SD=1.5), and has the highest scoring member as the *A5/S5 Comfort seat* (mean=4.20, SD=1.82) displayed in figure 4.

Kendall's W known as Kendall's coefficient of concordance is a non-parametric statistic and can be used for assessing agreement among raters'. Kendall's W ranges from 0 (no agreement) to 1 (complete agreement). The agreement among raters' for ***Sporty*** displayed a good level of agreement (Kendall's W = 0.71 ,p<.0001; SPSS 25).

Figure 6. HCA dendogram for the variable ***Sporty*** (left), ***Comfortable*** (middle) *and* ***Luxurious*** (right) with average linkage

In terms of the ***Comfortable*** variable, there were three distinct clusters at a cut off distance of 16. The first two clusters that displayed rounded back rest shapes displayed higher similarity (as of branch distance) where the third cluster (**box 3)** displaying integrated headrest mostly had increasing levels of dissimilarity. The third group belong to the manufacturers' sporty characteristics marketing segment and encompasses the *R8 Shell-bucket seat* and *A4/S4 Shell-bucket seat*. Specifically this group holds the same characteristics form the sporty sorting exercise which have integrated headrests and appear to have prominent shoulder supports. The first cluster (**box 1**) shows characteristics of the manufacturer's "normal"(standard) seats which have majorly a single rounded piece backrest where the segmentation of the back rest cushion is limited, and there are lesser partitions on the cushion surfaces and trenches. In comparison, the following cluster (**box 2**) having higher average comfort ratings for the designs, more prominent features of side supporting bolsters on the seat back and more partitioned shoulder supports which also belong to the manufacturers, "comfort" seats and "sport seat" category. In accordance with the larger distances observed in the ***Comfortable*** dendogram, the agreement among raters' for ***Comfortable*** displayed a poor level of agreement (Kendall's W = 0.149, p<.0001; SPSS 25). The statistics for the ***Comfortable*** dimension suggest that most of the seat comfort perceptions can be within 2 or more rating categories (for each seat as the SD values in the vicinity of 2 for each rating). This also confirms that the comfort perception has more variance within the participants in contrast to *"Sporty"* dimension and is very much subjective.

Luxurious displayed four clusters as displayed in figure 6 at a cut off value of 16. The first seat cluster (**box 1**) has particularly dominant features of integrated headrests and shoulder supports where the quilt patterns on certain seats have formed a finer second cluster. Specifically this cluster has the highest mean rating values. The bottom cluster (**box 4**) also has higher mean rating values where similar seat back insert patterns can be observed with more pronounced rounded back bolster shapes. The agreement among raters' for *Luxurious* again displayed a poor level of agreement (Kendall's W = 0.175, p<.0001; SPSS 25).

3.3 Plot graphs mapping visual attributes and linear regression

In order to analyze further the relationships amongst the three dimensions proposed, the results were plotted against each on a *Comfortable* vs *Sporty* regarding the mean rating values, explicitly plotting the seats on a coordinate basis. The plot maps plotted in excel with the mean values for each of the 38 seats in the categorization task has yielded certain tendencies and clusters of seat in terms of the proposed 2 axes and evidently explaining the relationships.

Figure 7. The plot graph of 38 seats on a *Comfortable* vs *Sporty* perception on the left (Mean value plot) and *Comfortable* vs *Luxurious* on the right.

The plot graph of *Comfortable* versus *Sporty* perception displays a clear indication of the clustering of integrated headrest feature on the seat designs in terms of *Sporty* perception (see figure 7). As displayed in figure 7, the 10 seats that were of particular distance in the HCA analysis, can be observed to form a separate cluster denoted in a circle in the plot graph from the remaining 28 seats. A closer inspection of the features reveal all the seats belong to the "Sport" category features of integrated headrest with prominent bolsters and shoulder support. Hence in relation to the graph plots, a quadratic relationship can be argued between the *Comfortable* and S*porty* mean values similar to the inverted U depicting an ideal point for expected comfort being increased with increasing sportiness. The graph plot of *Comfortable* versus *Luxurious* perception displays an indication of a linear relationship for the set of seat designs utilized (see figure 7).

The plot graph results display that the *A4 Sport seat* with bolstered seat back and separate headrest was found to perform better than all of the seats in terms of *Comfortable* (*Comfortable:* mean=6.54, SD= 2.14,

Luxurious mean= 5.04, SD=2.3). In terms of luxury the *A8 Sport seat* was found more *Luxurious* (*Comfortable* mean=6.3, SD=2.1, *Luxurious* mean= 6.5, SD= 2.4).

Using *Comfortable* ratings obtained from the sorting exercise as dependent variable, a linear regression was carried out using *Sporty* and *Luxurious* ratings were used as predictor variables. Entering all data, a significant model emerged ($F_{(2,909)}$ =74.045, p<.000; Adjusted R square=.138). Both of the predictor variables significantly predicted the *Comfortable* ratings where, the *Sporty* β = -.065 (p<.05) had a negative relationship with *Comfortable* and the *Luxurious* ratings β = .390 (p<.0001) had a positive relationship, explaining 13.8% of the variation on comfort ratings.

3.4. Effects of gender on perceived comfort

Non parametric tests were carried out in order to investigate the particular differences for gender on the three descriptors. Mann-Whitney U test for effects of gender over all the ratings acquired for the seat designs was carried out. It was found that for the *Sporty* variable, male participants rated the whole sample of the seats significantly sportier compared to females, where there were no differences for *Comfortable* or *Luxurious*.

On an individual seat design basis, Mann-Whitney U tests for the *Sporty* variable revealed that, from the 38 seat designs, the only difference was for the A8 Sport seat design where the males rated the design significantly higher (U= 36.5, N=24, p< .05). For the *Comfortable* variable, female participants rated the A1 Normal (standard) seat (U=114, N=24, p< .05) and A3 Normal (standard) seat (U= 107.5, N=24, p< .05) designs higher than male participants. These seat designs had a single piece backrest with less pronounced segmentation (see Appendix). In contrast, for the A4/S4 Sport seat (U= 33, N=24, p< .05), A5/S5 Sport seat (U= 26, N=24, p< .01), and R8 Shell (Bucket) seat (U= 33.5, N=24, p< .05), male participants rated the design higher in terms of comfort. These seat designs have particularly pronounced side bolsters and integrated headrest designs (see Appendix).

For the *Luxurious* variable, across the seat designs, the female participants rated the A4 normal (standard) seat (U= 111, N=24, p< .05) and Q3 Sport seat (U= 117, N=24, p< .01) significantly higher. These seat designs again have a single piece backrest with less pronounced trench and tie down segmentation on the backrest.

3.5. Qualitative assessment; comments by participants on car seat designs in relation to descriptors

The participants were asked to comment on what they were taking into account when assessing the seat images on the particular semantic scale prompted. The sample of participants commented on the 38 seat pictures while scrolling through them and indicating the particular references that they identified in assessing and categorizing. The most mentioned *Sporty* seat characteristics were of "shape of the backrest", "Integrated Head Rest", "Triangle", "cut outs" on the back and the prominent side supports and side bolsters. Two female participants also indicated that there was a "streamlined" look of the seat suggestive of the car design that it belonged to specifically a sports car. "Bucket Seats" or "Racing Seats" were referred to as the exemplar seat type for this variable by 6/24 participants. Approximately all of the participants indicated that the *Sporty* categorization process was much easier to assess, compared to *Comfortable* and *Luxurious* variables. The extremity of the shapes of the side supports and the prominence was indicated to be perceivable and the narrow taller looking back design was suggestive of sportiness characteristic. However these particular characteristic features such as "hugging", "snug" seats were indicated and interpreted by the participants as being less comfortable in use. Another concern was that sporty seats were not convenient and had too much of a seat angle at the back and an inclination on the seat pan. Also the "firm" and "hard" look of the seat cushions were mentioned. In terms of *Comfortable* assessment of the seats, the comments were generalizable in two themes; the level of padding and segmentation of the surfaces that was perceivable by the participant and lesser angularity in comparison to sport seats which the comfortable seats were deemed more curved or had more rounded bolster elements. On top of these appearance attributes, the attribute of being "adjustable" was directly mentioned 6/24 participants, whether this is limited to adjustability of the headrest or the whole seat to conform to the positional requirements. At least 4/24 participants mentioned that sporty and comfort would not be compatible as sporty meant stiffer and flatter look (feel) whereas comfort was more associated with plush puffy and padded seats. Five participants expressed explicitly that strong *Sporty* features such as very prominent side bolsters and wings were a hindrance to "comfort". In terms of the criteria and characteristics for "luxury" and "luxurious seat", a major comment was that without the material and the color application, 8 /24 participants deemed it very "tricky" or "difficult" to assess the seats. Most of the participants indicated that upholstery material was the key for luxury characteristic, where certain patterns (i.e. quilted upholstery pattern) lead the par-

ticipants to believe or assume the seat had “leather” as upholstery material. 11/24 of the participants indicated that upholstery material was the key for luxury characteristic, where certain patterns (i.e. quilted upholstery pattern) lead the 13/24 participants to believe or assume the seat had “leather” as upholstery material. The width of seats was also associated with luxury perception, where a bigger, larger padding on the seat was referred to as more luxurious. Electric adjustment buttons were also mentioned by 6/24 participants as a luxury element that lead those to believe the seats were luxurious and expensive.

4 Discussion

The first aim of this study was to explore the perceptual attributes regarding the pre-determined variables of automotive seats and second exploring the particular relationships between the three proposed variables identified in literature (1,3,13). The foundation of these variables relied on “voice of customer” surveys which weighed seat styling above all other characteristics when judging the appeal of the automotive seating system. However it had a limited approach in determining seat characteristics and the effects of the seat styling and visual design elements. Pinkelman (3) used the J.D. Power and Associates APEAL self-reported survey data, argued that the customer experiences the seat comfort as a function of “Discomfort”, the “Luxury” and “Sportiness” feeling of a particular seat. Trying to define a hypothetical equation of “comfort character” utility of an automotive seat he further proposed the difference between expected and experience of comfort (dE) depended on the variables of “Luxury” (L), “Sportiness” (S) and “Discomfort” (D), where they were weighed. One proposed equation for comfort utility of a seat was:

$$Cu = dE(L^x S^y / (D^z) \tag{1}$$

However the proposal of this comfort utility model relied heavily on assumptions of a previous study and secondary data. In this study with first hand empirical data on what can be deemed customers’ expectations of comfort, the findings suggested that “Sportiness” of a car seat is a recognized characteristic by the consumers, however utilized more as a categorical variable. In line with Erol et al (20) study, this categorization process as an “appearance role of product” lead to a high differentiation between the car seat designs. One of the key findings; the integrated headrest and prominent side bolsters were the most commented feature in the seat pic-

tures which does put an emphasis on characteristics such as “lateral holding” ability of the seat as previously found in literature (4). However the effect of the headrest/head restraint was not foreseen by any of the prior research in literature. In this regard, the assessment of sportiness of a seat design was found to be “easier” by the participants which was also reflected by the Kendall's coefficient of concordance with high agreement. It can be argued that particular referral to integrated headrest, the emphasis on the “triangular” shape, is an indication of the saliency of the design element and relatively objective feature of the sport seat designs. Moreover it was observed that the extreme cases of *Sporty* created an attitude amongst the participants that they have referred to as “gaming” seats using allo-referential semantic cues, and were deemed hampering comfort. Focusing on the mean value ratings of the seats and the HCA clusters, a segregation or “discontinuity” amongst the designs of the seats in terms of sportiness was observed in relation to the headrest design. These effects of the categorization are in stark contrast of utilization of continuous variables in seat comfort characteristic equations proposed by Pinkelman (1). One important hypothesis is that an inverted-u-hypothesis (21); quadratic relationship between the variable *Sporty* and *Comfortable* might be possible. The optimal point for sporty features being constructive for comfort when exceeded hampers the expectancy; leading to an inflection point. Future studies could aim to address the hypothesis with increased data points where a structural equation model could aid in determination of the nature of the variables in further detail.

For attributes that led to this categorization behavior; in terms of *Sporty*, the *A8 Normal seat* and *Q5 Comfort seat* design were found significantly less *Sporty* than the 14 sport category seat designs. The most important difference between the designs can be pointed as the sport seats displayed angular shapes and more pronounced segments (trenches) especially in the shoulder support area (see appendix). Again for *Comfortable*, the *A5 S Comfort seat*, *A5 Sport seat* and *A4 Sport seat* displayed more segments on the back rest and also had pronounced shoulder support areas in comparison to the *Q5 Comfort seat* and *Q5 Normal seat* (see appendix). This feature discrimination in conjunction with the graph plots for comfort perception depicts that the increase in prominence of the side bolsters linearly increases with increasing *Sporty* and *Comfortable* perception. The third separate group is formed of integrated head restraint/rest element and reported triangular features.

For *Luxurious*, *A8 Sport seat* was significantly rated higher than *Q5 Normal* and *A6 Normal seat* designs (see appendix). The intricate quilt pattern and pronounced shoulder areas proved to be perceived as more luxurious. For *Comfortable* vs *Luxurious* plot the graphs show that certain seat features incrementally increased

the perception of both comfort and luxury, where a continuous linear nature is achievable. Focusing on the HCA *Comfortable* dendogram, the first group seat designs display single piece backrest cushion whereas the second group displays increased segmentation on the backrest cushions which increases both comfort and luxury expectancy. Furthermore, the amount of "padded" or "cushioned" areas on the seats were commented as references (design cues) leading to an increased understanding of a more comfortable seat. From the participant's comments, it was deduced that the *Luxurious* content encompassed the quilt patterns and craftsmanship details which implies a degree of complexity of the design.

A very important insight was that monochrome pictures were harder for the participants judge the seat designs on the variable of *Luxurious*; a number of participants reported that the inability to know the tactility, color and the material of the upholstery was particularly hindering the impressions and 6/24 participants deemed it "tricky" to evaluate. In this aspect the participants relied on the particular details of stitching (trenches) and the quilt patterns that were suggestive of craftsmanship, therefore, luxury content. Also the subjective "width" and the "larger" dimensions of a seat forming a "spacious" look were referred to as luxury traits, where in fact all images were presented in consistently same dimensions on the iPad. This can be attributed to the visual effect of tapering single piece seat back cushion designs (e.g. *A4 Normal seat* etc.) and how narrow it was visually perceived. These results were also consistent with the previous study of Kamp (13) and Coelho & Dahlman (22); where participants associated width and softer materials with luxurious car seats. Specifically the effects reported for the three variables in this study should be utilized to build on the theorized comfort models for automobile seats, where the *Sporty* variable was not listed in the indicators of the "facet of the object" (11). Furthermore it can be proposed that the indicators listed which were identified from literature can be assessed if they are truly determinants of the expected comfort based on visual appearance.

The results of the linear regression on *Comfortable* confirmed that the *Luxurious* perception had a positive linear relationship also that was observed on the plot with mean ratings; hence they were also verbally associated by 6 participants. Strikingly, the *Sporty* had a negative significant relationship with *Comfortable*. Corroborating the mean value plot graph results, this can be interpreted that there is a cut-off value for achieving maximum comfort perception with increasing *Sporty* design attributes where it can be suggested that further incremental increase of these attributes reverses the relationship.

Finally, in support of Zenk et al. (2) argument that the effects of gender in response to automotive seat designs might be observed, in this study significant differences were found for certain designs of seats for genders. Overall the male participants found more *Sporty* attributes or were rating the sport category seats higher in comparison to females. Specifically for the *A8 Sport seat* this was significant, suggestive of the quilt pattern utilized as a design cue. For the *A1 Normal (Standard)* seat, and *A3 Normal (Standard)* seat, the expected comfort perception was significantly higher for females. This can be speculatively attributed to the design characteristics of the seats having more rounded shape on the seat back and seat pan design. In contrast, for the *A4 S Sport type*, *A5 S Sport* type seat and *R8 Bucket* seat, the expected comfort levels were significantly higher for the male participants which bear integrated headrest and prominent should rea designs. It can be hypothesized that the stature difference and possible attitude differences to the integrated headrest designs (hindered adjustability) and the preference of positions of the supporting surfaces such as the shoulder support impose different perception of comfort on genders. Creusen (23) argued that females were found to indicate that ease of use in terms of "product aspects" is more important to them than males. As Bhise (24) suggested, the anthropometric differences may lead to a postural difference when driving, where female drivers have different positioning needs compared to males. It can also be hypothesized that males might prefer sportier seats therefore expect higher comfort, where a certain degree of valence affects the perception based on angular shapes reflecting more masculine culture (25).

5 Conclusion

The research findings have significant implication for the appearance design of automotive seats, where it can be concluded that the end users do rely on specific design cues that elicit an expectation towards the seat comfort experience. In this study seats with angular shapes and integrated headrest designated in "sport" category generated expectations of lesser comfort and more function, whereas visually more padded and pattern bearing designs were apprised as affording more comfort. Moreover, perceived (expected) comfort had a negative linear relationship with increasing sportiness (utilitarian-functional) and positive one with the perceived luxury. It has been demonstrated that "product appearance roles" as previously hypothesized (20) does indeed guide the end users to develop expectations regarding comfort; specifically strong "sporty" features such as integrated headrest were deemed being function oriented and a categorical variable. It can be further conclud-

ed that for automotive seat design evaluation *Sporty*, *Comfortable* and *Luxurious* variables can be utilized to evaluate car seat appearance, given that salient design differentiation cues are present in the sample of seat designs selected e.g. prominent shoulder support area vs tapered seat back design. In scope of these findings, it can be proposed that the "holistic" evaluation processes relied on the overall impressions which lead to categorization of the seats where the "piecewise" evaluation processes associated with comfort and luxury dwelled on the partial visual attributes e.g. the prominence of bolsters and various patterns (10,26,27). Future studies on various comfort descriptors/variables can be conducted to enhance the understanding and provide the insight on various visual seat design attributes and their relationship with overall comfort perception.

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7 Appendix

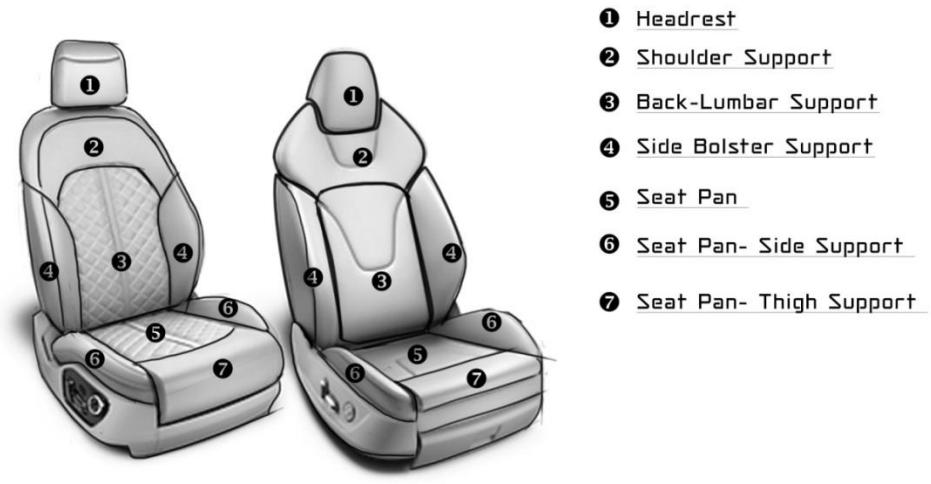

Figure A.8. Seat attributes in generic seat design for Production Automotive car seats on the left an *A8 Segment Sport seat* and on the right *A5 Segment Sport seat*

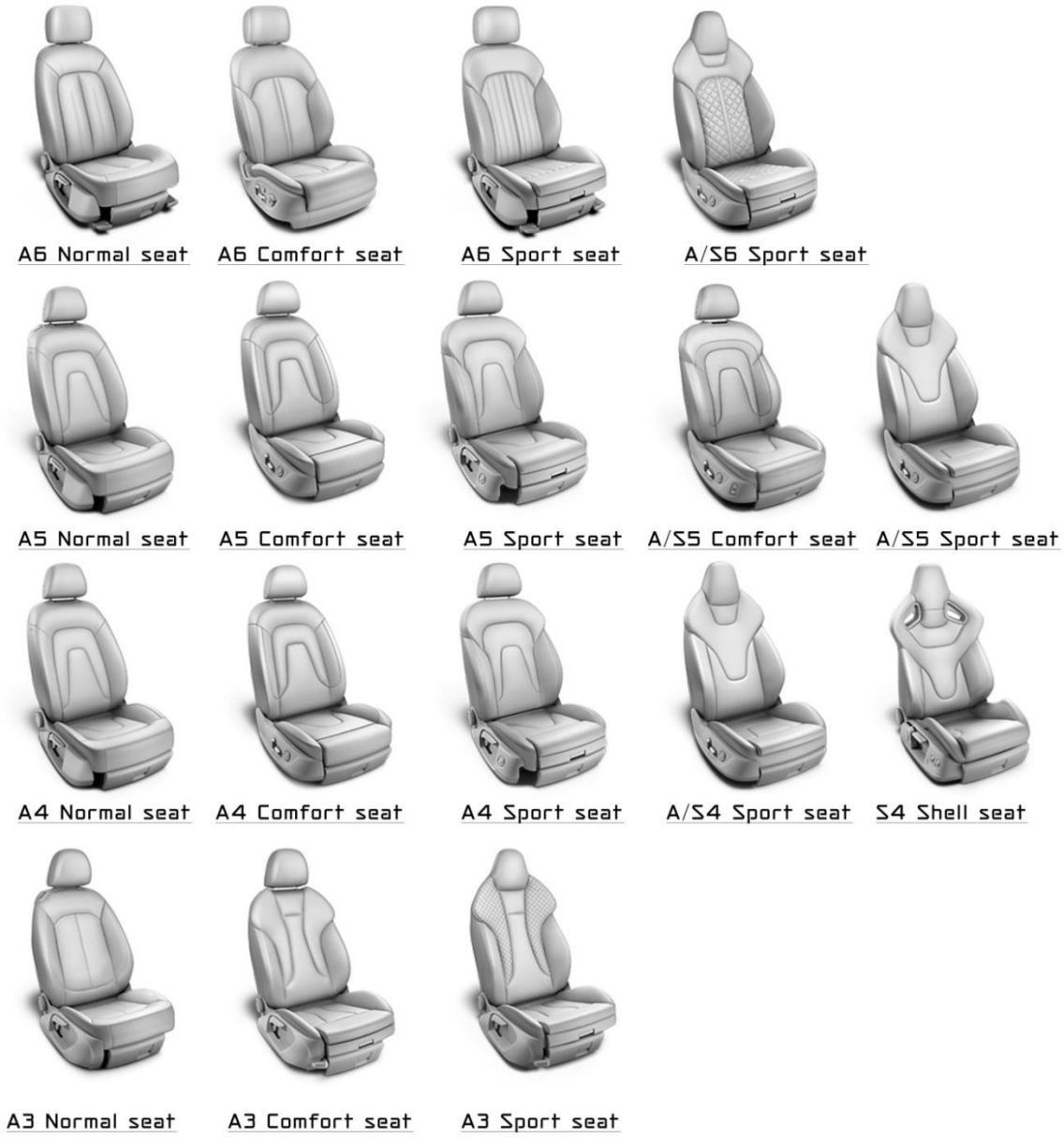

Figure A.2. The 38 AUDI AG (model year 2016) seat designs for each passenger car segment adopted in this study. The designs vary from "Normal" (alternatively referred to as standard) to "Sport" and "Shell/Bucket seat" types offered on the AUDI AG website.

Figure A.2 (continued). The designs vary from “Normal” (Standard) to “Sport” and “Shell/Bucket seat” types offered on the AUDI AG website.

Figure A.2 (continued). The designs vary from “Normal” (Standard) to “Sport” and “Shell/Bucket seat” types offered on the AUDI AG website.

Figure 1 Four of the 38 AUDI seat designs for performance cars, “Sport” to “Shell/Bucket seat” types offered on the AUDI AG website in 2016.

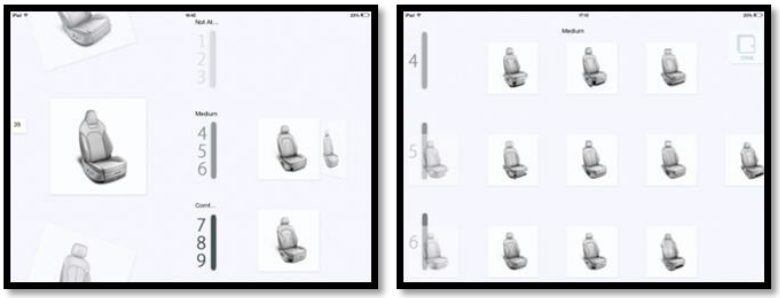

Figure 2 Typical subsequent scroll screenshots of the iPad app for sorting phase (on the left) final phase after sorting and fine tuning between categories (on the right).

Figure 3 R8 shell seat (on the left hand side) had the highest Sporty mean rating. The A3 Normal seat was the lowest mean rating (in the middle) and closely followed by the A8 Normal seat (the right hand side)

Figure 4 A4 Sport seat had the highest Comfortable mean rating (on the left hand side). The Q5 Normal seat has the lowest mean rating (on the right hand side)

Figure 5 A8 Sport seat has the highest Luxurious mean rating (on the left hand side). The Q5 Normal seat has the lowest Luxurious mean rating (on the right hand side)

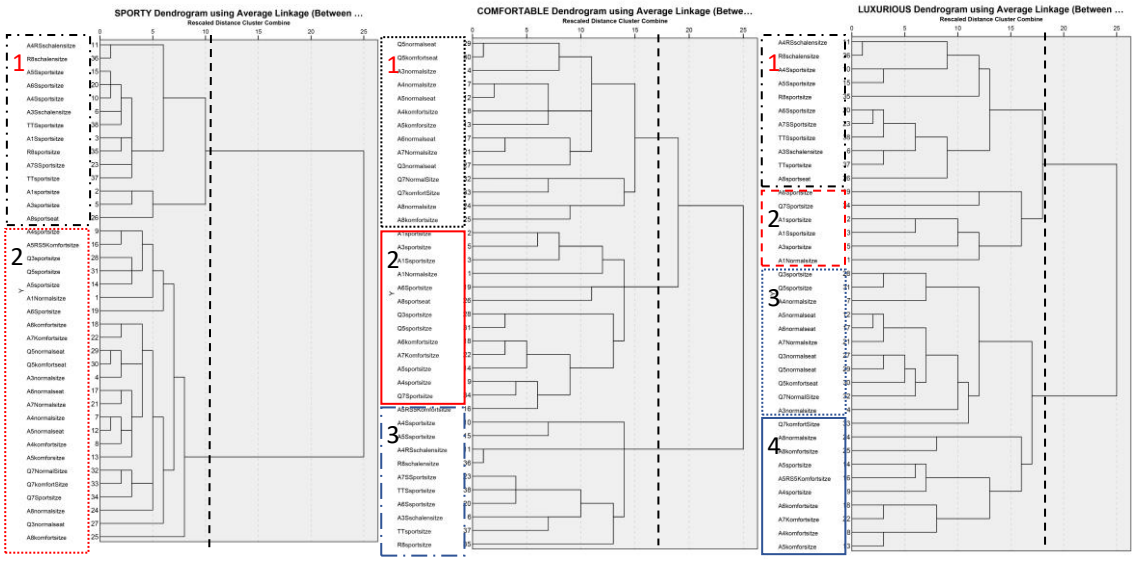

Figure 6 HCA dendogram for the variable Sporty (left), Comfortable (middle) and Luxurious (right) with average linkage

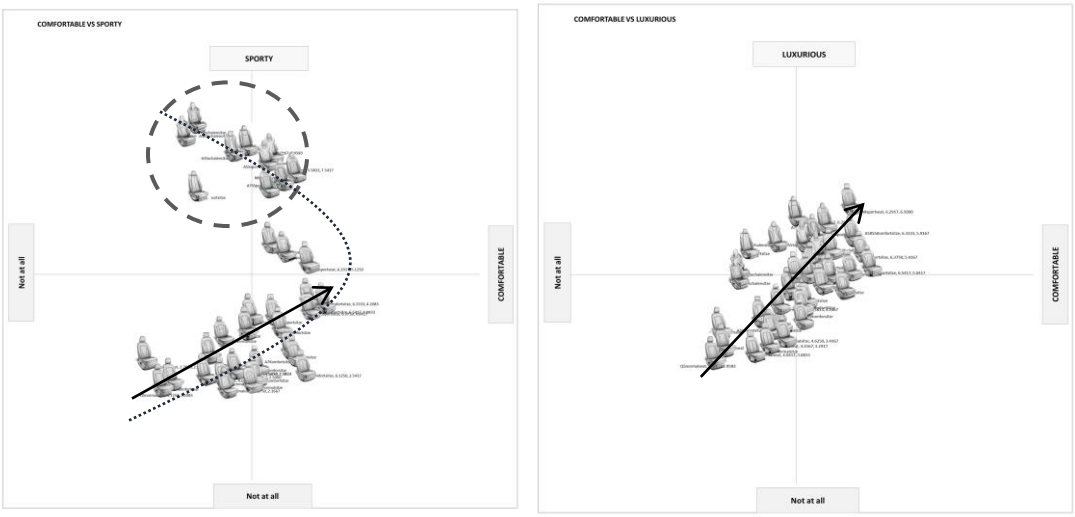

Figure 7 The plot graph of 38 seats on a Comfortable vs Sporty perception on the left (Mean value plot) and Comfortable vs Luxurious on the right.