

Study of a Car Seat Concept Design Proposal Using Kansei Ergonomics

< digital picture> < IF AVAILABLE>	Santos, Michele Technical University of Lisbon / Faculty of Architecture / Pólo Universitário / Rua Sá Nogueira / Alto da Ajuda / 1349-055 Portugal E-mail: tmsantos@fa.utl.pt
< digital picture> < IF AVAILABLE>	Rebelo, Francisco Technical University of Lisbon / FMH / Estrada da Costa / Cruz Quebrada / 1495-688 Portugal E-mail: frebelo@fmh.utl.pt
< digital picture> < IF AVAILABLE>	Teles, Júlia Technical University of Lisbon / FMH / Estrada da Costa / Cruz Quebrada / 1495-688 Portugal E-mail: jteles@fmh.utl.pt

ABSTRACT

Three car seat visual concepts were evaluated using Kansei Ergonomics. We used a kansei questionnaire with semantic differential and performed it to 36 subjects. A factor analysis was applied to describe the underlying structure of the 11 chosen words, resulting on the identification of four factors. A cluster analysis was employed with the same purpose and two clusters were identified, named Conventional and Stylist. Cluster Conventional encloses the safety, ergonomics and conservative issues. Cluster Stylist includes the aesthetic issues like elegance, attractiveness and modernity. The work group enjoyed the results and thought that they might be very useful on such projects.

Keywords

Kansei Engineering, Kansei Ergonomics, Car seat design

INTRODUCTION

Car industry design is a competitive and constant changing and improving field, where car seat design plays an important part in the whole design concept. Car seat design varies from car to car and from company to company, and it is a subject for stating creativity, personality, safety, functionality and differentiation. The idea that style was merely a commercial ornament has disappeared and in a mature market like car industry, when neither performance nor prices have significant differences, it is aesthetics and style that drive consumers' choice (Park *et al.*, 2003). Cars are designed to appeal the buyer's self image, many of them evoking an impression of speed and power (Bayley *et al.*, 2004). The seat design has to follow the exterior concept of the car, its appearance and its ultimate safety level has to be as appealing as the rest for potential buyers.

Car seats are commonly evaluated in terms of comfort and safety, built upon basic seat functionality and usability of the seat and its controls. Some studies have demonstrated that the car seat proprieties most users prefer are comfort, safety, functionality of the interfaces, aesthetic and emotional aspects. In an opinion study made by questionnaires, Coelho and Dahlman (2002) found that aesthetics qualities of the seat were ranked in order of importance by their subjects in:

1. The seat is comfortable;
2. The seat has the right adjustments possibilities;
3. The seat cover has a soft touch;
4. The seat cover looks good;
5. The seat cover is beautiful;
6. The seat cover does not need to be washed;
7. I look good when I sit in the seat.

Showing those attributes that may lead to sociological pleasure, providing that others recognise the beauty of the seat, are relevant to people and are ranked in fourth, fifth and seventh place as valuable features for the users.

Another study by Santo (2006) about the positive aspects of the car seat, performed to professional drivers (view Table1), indicates that comfort is the primary factor with 33.8%, followed by ergonomic issues (adjustability 20.22% and back support 11.6%). The durability of the seat has an importance of 13.6%. Hygienic and perspire concerns have both 4.5%. The aesthetic aspect has the same percentage as the roominess and mobility with 2.2% each.

Aspects	Percentage of importance
Comfort	33.8
Good adjustments	20.2
Durability	13.6
Good back support	11.2
Hygiene	4.5
Antiperspirant	4.5
Roomy	2.2
Good mobility	2.2
Aesthetically pleasant	2.2
Without opinion	5.6
Total	100.00

Table 1. Car seat positive aspects by professional drivers

Kansei Engineering is an ergonomic technology of customer-oriented product development; it focuses not on the manufacturer's intention of the product, but rather, on the customer's feelings and needs (*Kansei*) (Nagamachi and Imada, 1995). "*Kansei*" is a Japanese word that means the customer's feelings and needs relating to a product. Kansei Engineering was developed in Japan, at Hiroshima University, in 1970, by Mitsuo Nagamachi and it has spread out, firstly in Japanese industries and them around the world.

Kansei includes the customer's feelings about product design, size, colour, mechanical

function, feasibility of operation, and price, translating these consumer image feelings of a product, into design elements (Nagamachi, 1995). Kansei Engineering is an ergonomic technology aimed for the development of customer-oriented products (Nagamachi and Imada, 1995). The knowledge of these aspects, in an era where technology is constantly improving, can make the difference on the users' product choice.

This study was part of a large project conducted by a consortium of several Portuguese enterprises that wanted to produce a new car seat, all with Portuguese components, to be proposed to the international car manufactures, specially those manufacturing cars in Portugal. This idea came from the advantage of having near the supply chain, and as an initiative to promote the products made in Portugal. We were part of the ergonomic advisor board and proposed the utilization of Kansei Engineering or Kansei Ergonomics (Nagamachi, 2007) to support the design options of the concepts.

We used notions of feelings, associated with users' possible interaction with the car seat visual concepts design, by introducing Kansei ergonomics.

A study on three visual concept design proposals was conducted, on the initial phase of a car seat design project, to evaluate, if the design options made by the design team matched the users opinion and tastes about a car seat design.

These three models were chosen by the consortium group considering that, in general, the automobile industry is still very traditional.

The questionnaire had 3 different parts, one about the complete look of the seat, another about the seat back (squab) and the third part about the seat base (cushion), each part with 11 questions. On this paper we will focus only on the first part of the questionnaire.

METHODOLOGY

The study initial phase regarded the car seat visual design preferences. We used kansei ergonomics methodology to evaluate the feelings of the potential car seat users regarding the three visual car seat visual concepts.

In order to follow kansei ergonomics application we did these phases:

1. Collection of kansei words;
2. Brainstorming;
3. Kansei words reduction;
4. Semantic differential scale;
5. Pretest and questionnaire reformulation;
6. Questionnaire application;
7. Information processing.

1. Collection of kansei words

Several words were collected from different resources: world wide web, books and magazines; those words were part of the car visual seat context, the outcome were 46 words.

2. Brainstorming

We conducted a brainstorming with experts from ergonomics and design, and with users, to generate more words within the same context. The words from the previous phase, plus the outcome words from the brainstorming totaled 99 words for the three car seat visual concepts.

3. Kansei words reduction

The initial 99 words were reduced to a manageable number of relevant words, considering the conceptual models characteristics, resulting in 11 kansei words. This reduction was made with a criteria centered on the words search that were most representative of the semantic space, aggregated in the same concept. The final reduced words are shown on Table 2.

Modern	Attractive	Elegant	Simple
Popular	Comfortable	Feminine	Heavy
Bold	Sportive	Safe	

Table 2. Final kansei words

4. Semantic Differential scale

The 11 semantic differential scales, based on the Semantic Differential (SD) method developed by Osgood *et al.* (1957), were arranged using a bipolar 7-point scale. An example of this scale is shown on Table 3.

Seat Model # 1	Modern	1	2	3	4	5	6	7	Old-fashion
Seat Model # 2	Modern	1	2	3	4	5	6	7	Old-fashion
Seat Model # 3	Modern	1	2	3	4	5	6	7	Old-fashion

Table 3. Semantic differential scale

5. Pretest and Questionnaire reformulation

We conducted a pretest with two potential users before applying the questionnaire to our subjects. Their comments were very useful and used to correct some inaccuracies on the questionnaire.

6. Questionnaire application

On this phase we had three car seat visual concepts that were evaluated by 36 subjects. On the experimental set the users had to evaluate three different concept designs presented in a video, where the three (3D) virtual models (view Figure 1) rotated 360° degrees allowing the users to see all the sides of the concepts.

The questionnaire was applied to thirty six people, 24 female and 12 male, with an average age of 32 years old. Every volunteer subject answered the questionnaire while visualized the video individually. All the questionnaires were made in the city capital area of Portugal – Lisbon, by convenience, within the same controlled room conditions.



Figure 1 – Car seat conceptual models.

7. Information processing

All the subjects fully completed the questionnaires. The statistical analysis tasks comprised two stages: (1) factor analysis, (2) cluster analysis. Both analyses were made using SPSS software v.15.

RESULTS

We performed a factor analysis to describe the underlying structure of the 11 chosen words, identifying words that were highly correlated with one another. A cluster analysis was employed with the same goal. In this analysis each homogenous group of words comprises a cluster.

1. Factor analysis

To verify if Exploratory Factor Analysis (EFA) is a suitable statistical technique to analyze our data, we used the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and Bartlett's Test of sphericity (see Table 4). The value of KMO statistic was 0,698, which means that the sample size is suitable for EFA. Sheskin (2007) refers that KMO statistic should be 0,6 or greater (if this condition is not met, some variables should be deleted before performing EFA). Bartlett's Test has a p -value less than 0,001 showing that there are significant bivariate correlations between some of the variables. The results of both tests indicated that EFA could be suitable to get a better understanding of the relationship between the variables in our data.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,698
Bartlett's Test of Sphericity	Approx. Chi-Square	312,086
	df	55
	Sig.	,000

Extraction Method: Principal Component Analysis.

Table 4 - KMO and Bartlett's Test

The relational structure between the 11 kansei words was evaluated by the EFA, using the principal components method to extract factors, followed by a varimax rotation, in order to obtain new factors that were easier to interpret. The variance explained by the initial solution, extracted factors and rotated factors are presented in Table 5. It is a common practice to consider a subset of factors which accounts for most of the variability in data. An usual rule consists in extracting factors with *eigenvalues* greater than 1. This rule and the scree plot displayed in Figure 2, suggests that 4 factors should be extracted. The first, second, third and fourth factors explain, respectively, 20,9%, 18,3%, 17,3% and 10,8%, of the variability. The four extracted factors explain 67,4% of the variability in data, which is an acceptable value (e. g. Sheskin, 2007).

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,960	26,912	26,912	2,960	26,912	26,912	2,299	20,901	20,901
2	2,251	20,465	47,377	2,251	20,465	47,377	2,017	18,336	39,237
3	1,196	10,876	58,253	1,196	10,876	58,253	1,903	17,305	56,542
4	1,000	9,095	67,347	1,000	9,095	67,347	1,189	10,805	67,347
5	,848	7,706	75,054						
6	,600	5,458	80,512						
7	,588	5,346	85,857						
8	,561	5,098	90,955						
9	,386	3,506	94,461						
10	,329	2,987	97,448						
11	,281	2,552	100,000						

Extraction Method: Principal Component Analysis.

Table 5 - Total Variance Explained

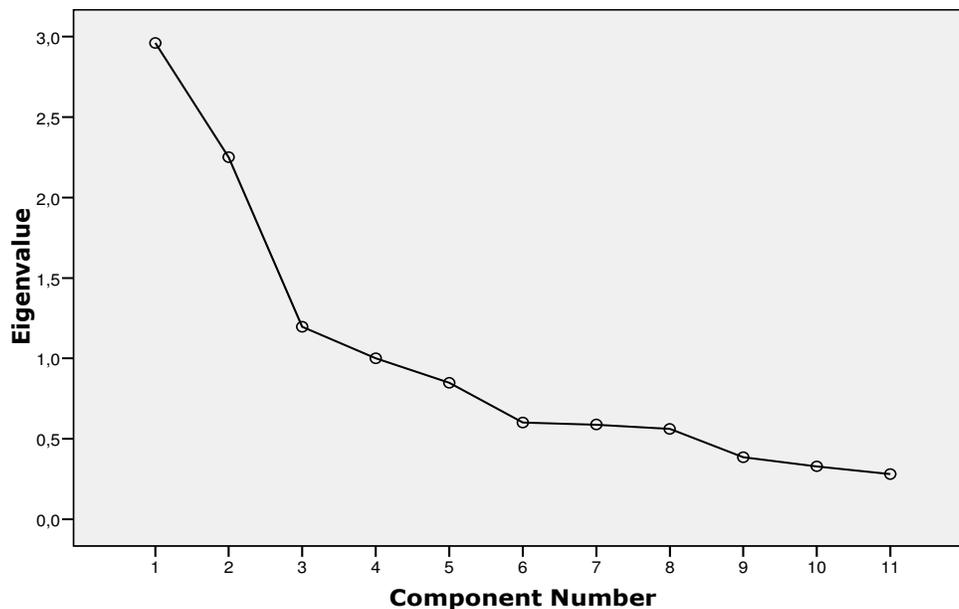


Figure 2 - Scree Plot

The factor loadings for the 11 words are given in Table 6. We point out in boldface the factor loadings that have an absolute value greater than 0,7. Factor 1 has a high positive loading for the word Bold and a high negative loading for the word Popular. Words Elegant and Feminine have high positive loadings in factor 2, contrasting with a high negative loading of the word Heavy. Comfortable and Safe words have high positive loadings in factor 3, and factor 4 has a high positive loading for the word Simple. The loadings of the first three factors are displayed in Figure 3.

	Component			
	1	2	3	4
Modern	,514	,315	,193	,493
Popular	-,721	-,028	,315	,006
Bold	,796	,119	,160	,124
Attractive	,622	,471	,297	,004
Comfortable	,122	-,222	,803	,115
Sportive	,555	-,108	,186	-,219
Elegant	,397	,713	,161	-,154
Feminine	-,021	,757	-,168	,200
Safe	,061	-,010	,862	-,079
Simple	-,079	-,014	-,017	,894
Heavy	,048	-,734	,419	,007

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
 a. Rotation converged in 7 iterations.

Table 6 - Rotated Component Matrix

Component Plot in Rotated Space

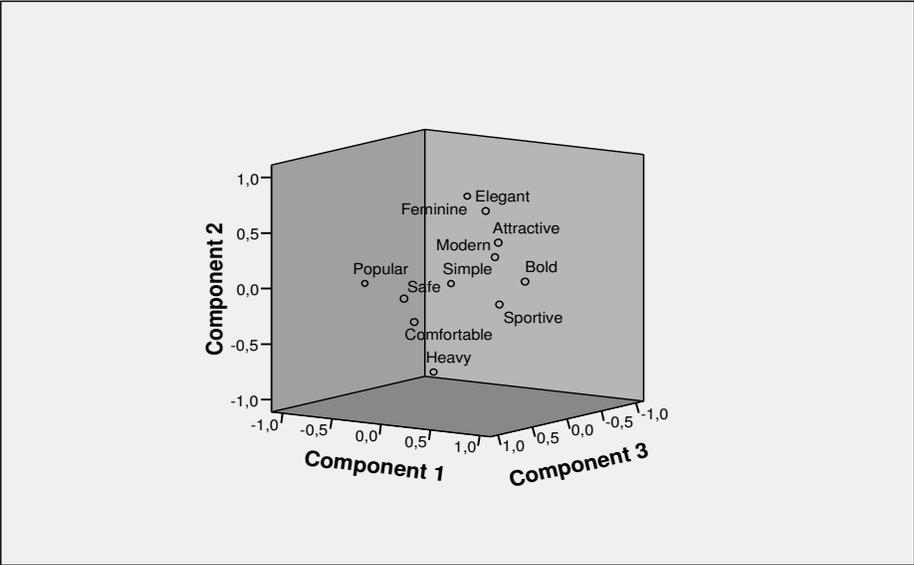


Figure 3 - Component plot in rotated space

2. Cluster analysis

After the EFA, we performed a cluster analysis to identify groups of words that were correlated. The hierarchical cluster analysis results indicated that the 11 selected words could be clustered into two significant clusters (view Figure 4). Table 7 presents the words within each cluster. Cluster 1 contains the variables: comfortable, safe, heavy and popular; cluster 2 contains variables: bold, attractive, modern, elegant, sportive, feminine and simple. We can identify cluster 1 as "conventional" for including variables related to ergonomics and cluster 2 as "stylish" where all the variables are related to the image component.

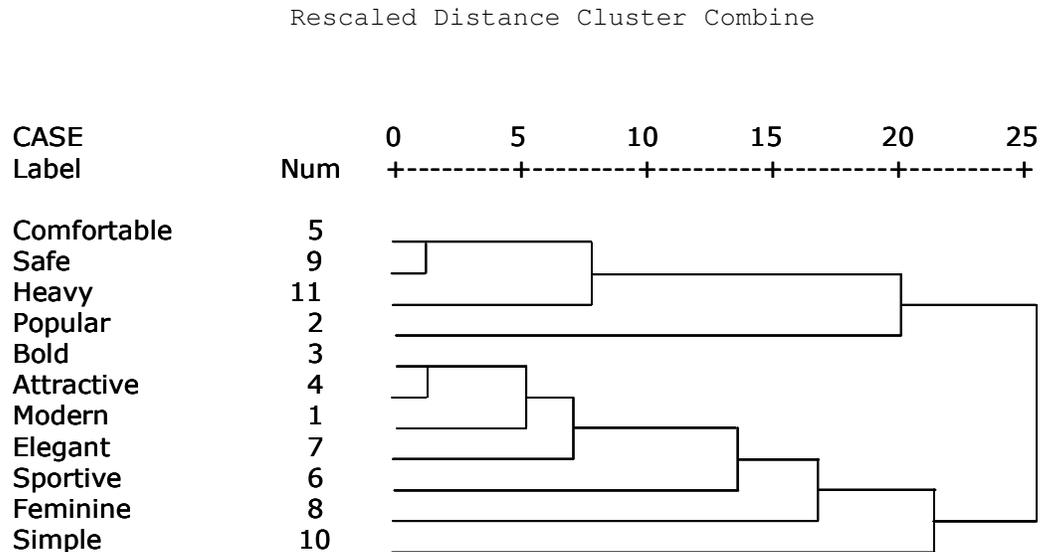


Figure 4 - Dendrogram using Average Linkage (Between Groups)

Cluster	1	2
Words	Comfortable Safe Heavy Popular	Bold Attractive Modern Elegant Sportive Feminine Simple
Cluster name	Conventional	Stylish

Table 7 - Clusters analysis

To better understand the previous analysis of the three car seats visual concept, we calculated the medians of the given answers (view Figure 5) to look for what occurred in each word situation.

The words that are grouped on cluster 1 are closer to Model 1 car seat visual concept. Model 2 car seat visual concept fits better on the words grouped on cluster 2.

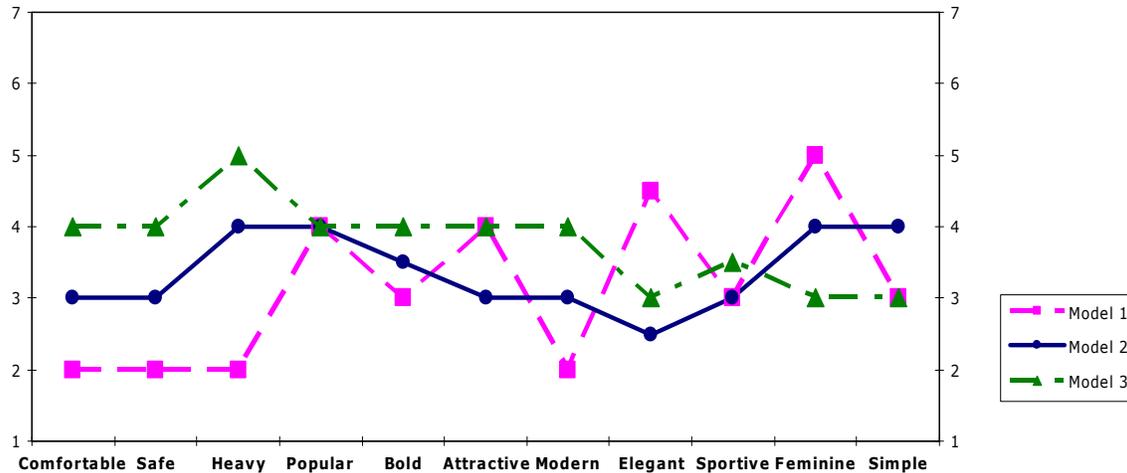


Figure 5 - Graph medians of the 3 concept models

CONCLUSION

On this study we tried to evaluate if the design options made by the design team matched the users opinions and tastes concerning a car seat design of three visual concept design proposals, in the initial phase of a car seat design project.

The results from the statistical analysis leads us to conclude that most characteristics of car seat concept model 1, belongs to cluster 1 – Conventional; and that car seat concept model 2, fits better under cluster 2 – Stylish. The results of this study show that cluster Conventional encloses the safety, ergonomics and conservative issues; and that cluster Stylist includes the aesthetic issues like elegance, attractiveness and modernity.

Kansei Ergonomics allows to perform a more overall analysis than traditional questionnaires. These results are richer to the design team for identifying the preferred clusters, named Conventional and Stylist. The work group enjoyed the results and thought that they might be very useful on such projects.

However, if the given concepts by the design team were more dissimilar, it would have conducted to more differentiated conclusions, instead of these slightly different conclusions.

Future work will involve the analysis of the collected data relative to the seat back (squab) and about the seat base (cushion).

ACKNOWLEDGMENTS

The research of Michele Santos has been supported by grant SFRH/BD/28621/2006 from the Portuguese Institution – Fundação para a Ciência e Tecnologia / Ministério da Ciência, Tecnologia e Ensino Superior.

REFERENCES

Bayley, M.; Curtis, B.; Lupton, K.; Wright, C., 2004, Vehicle aesthetics and their impact on the pedestrian environment, *Transportation Research Part D*, 19, 6, 437-450.

Coelho, D. A.; Dahlman, S., 2002, Comfort and pleasure. In *Pleasure with Products beyond usability*, ed. by Patrick Jordan and William Green, London: Taylor & Francis. ISBN: 0415237041

Han, S.; Hong, S., 2003, A systematic approach for coupling user satisfaction with product design, *Ergonomics*, 46, 13-14, 1441-1461.

Nagamachi, M., 1995, Kansei engineering: A new ergonomic-oriented technology for product development, *International Journal of Industrial Engineering*, 15, 1, 13-24.

Nagamachi, M., 2007, From Kansei Engineering to Kansei Ergonomics, *Ergonomia*, 29, 2.

Nagamachi, M.; Imada, A. S., 1995, Kansei Engineering: An ergonomic technology for product development, *International Journal of Industrial Ergonomics*, 15, 1, 1.

Osgood, C. E.; Suci, G.J.; Tannenbaum, P. F., 1957, *The Measurement of Meaning*, Urbana, Ill: University of Illinois Press. ISBN: 0252745396

Park, S.; Kamaike, M.; Nagao, T., 2003, A Study of the Expression in the Front View Design of a Passenger Car, Paper presented at the 6th Asian Design Conference, Tsukuba – Japan.

Rouse, W. B., 1991, *Design for Success: A Human-Centered Approach to Designing Successful Products and Systems*, New York: Wiley-Interscience. ISBN: 0471524832

Santo, K. E., 2006, *Critérios de Segurança e Conforto no Banco Automóvel – Uma abordagem da Ergonomia*, Tese de Mestrado, Cruz-Quebrada: Universidade Técnica de Lisboa – FMH, 126-128.

Shang, H. H., 2001, Ergonomics in Product Design, *International Journal of Industrial Engineering*, 27, 4, 205.

Sheskin, D. J., 2007, *Handbook of Parametric and Nonparametric Statistical Procedures*, 4rd Ed., Boca Raton, Fl: Chapman & Hall/CRC. ISBN: 1584888148