THE VISUAL PERCEPTION OF AUTOMOBILE SEAT COMFORT

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ABSTRACT

THE VISUAL PERCEPTION OF AUTOMOBILE SEAT COMFORT

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The visual domain design constitutes the general designers communication basis for communicating messages of product attributes. In the design of an automobile seat where mainly the accommodating functions remain constant, an automobile seat's "style" affords the ability to provide certain meanings with affective connotations. Treating style aesthetics as a source of information, the communication of "comfort" can be provided via forms and other attributes. The literature provides strong evidence that comfort is related with aesthetics of any object in use, especially creating expectations towards the product. The "Aesthetics of comfort" can be explained as a variable intensity "feeling" or "attitude" regarding an entity of factors or characteristics of a multidimensional construct. Implemented by different layouts and cues, the consumer should be assisted in understanding the qualities of an automobile seat, such as comfort. As a result of the field study conducted, significant difference was found to exist in between the perception of visual comfort three production seat designs. A positive attitude about comfort towards an automobile seat was found to be influential in positively effecting the perception of seated comfort.

Keywords: Automobile, Seat, Comfort, Visual Domain Design, Semantic Differential

ÖZ

OTOMOBİL KOLTUĞU KONFORUNUN GÖRSEL ALGISI

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Görsel tasarım, tasarımcıların ürün niteliklerini yansıtmak için kullandıkları iletişim tabanını oluşturmaktadır. Genel olarak sağlanan fonksiyonların sabit kaldığı otomobil koltuğu tasarımında ise, söz gelimi "stillendirme" istenilen anlamların iletilmesini sağlamaktadır. Stil estetiği bir ileti kaynağı olarak değerlendirilecek olursa, "konfor" iletisi belirli formlar ve diger niteliklerle sağlanabilir. Literatür, kullanılan objelerin estetik değerleri ile sağladıkları konfor arasında bir bağ; özellikle konfor beklentisi yaratmakta olduğuna dair sağlam kanıtlar göstermektedir. "Konforun Estetiği" değişken yoğunlukta, kullanıcı tarafından yaşanılan, belirli bir takım faktörlerin meydana getirdiği veya cok boyutlu bir oluşumun yarattığı bir hissiyat veya yaklaşım olarak açıklanabilir. Değişik tarzda uygulamalar ve görsel referanslarla, tüketici otomobil koltuğunun sağladığı konfor nitelikleri hakkında bilgilendirilebilir. Yapılan saha çalışmasında üç değişik fabrika üretimi araba koltuğu tasarımı arasında görsel olarak algılanan konforda önemli derecede fark bulunmuştur. Özellikle bir koltuk tasarımına konfor açısından duyulan positif yaklaşımın, oturulduktan sonra hissedilen konfora etkisi olduğu saptanmıştır.

Anahtar Kelimeler: Otomobil, Koltuk, Konfor, Görsel tasarım, Semantik differansiyel metodu

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CHAPTER 1

INTRODUCTION

The introduction of the ergonomic concepts in product development has followed an increasing trend due to factors such as consumer demands, developments in technology and the increasing "user-centred" design strategies adopted by manufacturers.

The contribution of the discipline of ergonomics to the design and development of automobiles has been to identify, assess and apply all criteria within its scope, thereby enabling satisfactory conditions for users. However, current trends and developments (social and technological) in our lifestyles, have lead the practice of the discipline in the automotive industry to capitalize on certain criteria, where users have begun to take for granted that a product meets the expected levels of performance. Therefore today the quality of the experience, the characteristics of issues such as "comfort", "usability" and "pleasantness" have become more appreciated by the users, influencing the decisions of the consumers. In this context, deducing that the interaction of the user with the product (in this case the interior of the automobile) constitutes the focal point, the relative variables and factors influencing the interaction proves to be of major concern.

Comfort has become a major marketing, satisfaction and sought after criteria, where the automobile has become a means of transportation in which we spend a significant amount of time both as driver and passenger. To satisfy this need, manufacturers focus on providing notions like “space”, “harmony”, “arrangement”, and "flexibility"

in the confined interior of the automobile by design. Focusing on the design elements of the automobile interior, the car seat is one of the most significant; having a substantial impact on the experience of the users. The essence of a car seat design must live up to multi-faceted topics such as technical construction, economic feasibility, aesthetical appearance, safety, marketing and ergonomics criteria. Designers attempt to create and supply successful automobile interiors and seats meanwhile they try to differentiate due to the competition pressure in the market while maintaining the delicate balance between these topics. However, comfort is the crucial determinant for both of the parties included in this exchange. Taking a look from the car manufacturer's perspective, comfortable seats not only attract customers, but also play a major role in keeping them as consumers of their products in future (Judic et al.,1993).

As a consequence, the struggle to define seat comfort in an objective manner has been an urge in the automotive seat industry. However, "comfort" is recognized to be a multi faceted and somewhat generic term leading to confusion when it comes to determining design specifications that will provide these attributes to an occupant. Being highly subjective, opinions vary among individuals in sensing comfort. The term and concept of comfort is an abstract noun and is highly a mental state. It has been stated that there is no universally accepted operational definition of comfort, where the definitions have reflected the disciplines of the researchers who formulated them (Juianghong and Long, 1994). So rather than formulating or defining the nebulous nature of comfort, evaluation methods were developed and adopted by the industry and the researchers dealing with the matter (Lee and Ferraiuolo, 1993). Parameters for evaluating seats in diverse aspects regarding the design have been investigated for a while now.

In the past, due to the lack of analytical measurables, the seating industry had relied on jury evaluations as the main measure of seat comfort (Lee and Ferraiuolo, 1993). Today, approaches are more systematic and developed, but most of them are still qualitative. As a vehicle is dynamic in nature, the seat and the user are subject to both static and dynamic environments, which complicate determining the nature of variables affecting the perception of comfort. However, it is obvious that the comfort sensation should not be disturbed in spite of the conditions that vary. As a consequence a continuous nature from the comfort providing variables is desired although the physical attributes may remain static. Most engineering variables influencing comfort, such as vibrations, can be measured objectively and analytically modelled. The recent use of pressure distribution assessment techniques provide numerical data on pressure at certain contact points and pressure distribution on surfaces, but as the human morphology varies immensely, what is discomforting for certain people could be comforting for others. Also new methods for prediction of the ideal conditions that will provide comfort to a diverse population of drivers have spawned in the recent decades. As the production of the car began to rely on computer generated images and models, the design and production modeling of the interior element of the seat has transformed from the much physical world in to the virtual. The once flesh and blood humans responding to certain stimuli given by the designed experiments of ergonomists, now are being modeled or directly transferred to the virtual environment by 3D scanners. Occupant accommodation standards and the manikins (population based) in accordance with new applications have been transferred in to the CAD (Computer Aided Design) environment already. More over, finite element based techniques enable assigning material properties to models in the virtual environment. However, all these virtual 3D tools serve much in the

assessment and prediction of positional variables such as vision, reach and comfort analysis (based on joint angles) .Thus they lack the representation of a real interaction between the user and the seat and are limited by the assumption that body dimensions are the primary determinants (Reed et al, 2000). These traditional tools of ergonomics still rely mostly on the physiologic and anthropometric variables of the users. However, people who buy an automobile and interact with the seat for longer durations, tend to build up a very personal perspective about the seat. In fact this perspective is initiated with the very first contact. Hubbard (1993) has pointed out the sensitive side of the interaction of humans and how they tend to develop a "love/hate relationship" with the seat's comfort and the way it supports and positions them. Therefore, comforting of the user's desires seems to be only possible with a seat possessing certain qualities, which are composed also of emotional and semantic aspects.

The emotional and semantic aspects of comfort can be regarded as the most important of psychological dimension of the state which act on various intensity levels of the feeling. During the interaction, the user absorbs meaning through senses and dwelling on the visual perception, in this communicational freeway, empathy serves as a means to perceive ourselves within the context of usage. The visual domain design constitutes the designers communication basis for semantic detailing. In the design of a seat where mainly the accommodating functions remain constant, an automobile seat's "style" affords the ability to provide certain meanings with affective connotations. Treating aesthetics (style) as a source of information, the communication of experiences (related to forms) and of emotions such as "comfort" is expected. The literature provides strong evidence that comfort is related with aesthetics of any object in use, especially in creating expectations towards the

product. This can be attributed to the comfort of vision or the visual perception of comfort in the design regarding all levels of humane thought or at least an overlap of the two states. This region can be referred to as “Aesthetics of comfort”, where it can be explained as a variable intensity “feeling” regarding the organisational properties of the “gestalt” and the “gestaltungqualitaten”. Implemented by different layouts and cues, the consumer may be assisted in understanding the qualities of the product (Seat) such as comfort.

1.1. The aim of the study

The aim of the study is to identify the factors affecting automobile seat comfort perception, and investigate the affect of aesthetics and visual domain design. In order to test the hypothesis also a study will be conducted in order to visually asses the perception of "comfort" of automobile seats, where the "designers" are most effective in designing. In return partial effects on the automobile seat comfort parameters will be determined. Future considerations for studies will be projected.

1.2. Main goal

The goal of the study is to establish visual criteria regarding the seat design, concerning the discipline of design, which will enhance the perception of comfort of automobile seats by the individuals using them.

1.3. Research Questions

- What are comfort definitions utilized by current literature and dimensions of comfort in relation to automobile seat design? What are the models proposed for comfort/discomfort interaction?

- What are the current approaches utilized in assessing the perception of "comfort"/ "discomfort" in automobile seat evaluation (The ergonomic tools utilized by these methods in assessment and identification of the factors contributing to the perception of comfort)?
- What are the current ergonomic criteria for promotion of comfort in engineering/ physical terms available in literature regarding automobile seat design?
- What are the psychological constituents of comfort regarding automobile seat design and the layers of design for semantic and emotional function?
- What are the possible visual constituents (factors) in comfort perception and semantic interpretation?
- What are the basic mechanisms of aesthetics that affect visual perception?
- How can the perception of "comfort" in automobile seat design be enhanced by aesthetics or visual domain design?

1.4. Structure of the Thesis

In the second chapter, ergonomic methods of comfort/discomfort assessment methods will be discussed. The current models of comfort/discomfort for seating comfort will be analyzed and the various definitions of "comfort" will be discussed. According to the comfort definition adopted, the particular methodology appropriate for supplying parameters in enhancing the "perceived comfort" will be determined and analyzed.

In the third chapter, the topics defining design parameters that promote physiological "comfort" in relation to the vehicle and seating will be presented in relation to the ergonomics literature. the current seat design process and seat comfort development

will be briefly discussed. The ergonomic design guidelines revealed by different methods of assessment of "comfort" design of automobile seats will be analysed. The particular field of ergonomics, which permit the "enhancement" of the “perceived comfort”, will be clarified.

In the fourth chapter, the topics regarding psychological comfort will be investigated where emotional design regarding the perception of comfort will be determined. The semantic aspect of comfort will be discussed. The aspects of cognitive (level) approach to visual domain design will be depicted with respect to automobile seat design.

In the fifth chapter, a case study regarding the visual perception of comfort will be presented. By the use of selected comfort descriptors, three types of seats will be rated. The effect of gender and age on the visual perception of comfort will be investigated.

In the sixth chapter, conclusions drawn through out the study will be reviewed, and suggestions for future studies will be made.

CHAPTER 2

MODELS OF COMFORT/DISCOMFORT

2.1. Definitions of comfort/discomfort in ergonomics literature

The definition of “comfort” has been and still is a point of debate, a challenge, for the reason that, every individual's description of comfort and its components is as complex as the human nature. Defining the nature of comfort and discomfort is by no means easy but necessary for scientific purposes. As stated by Zhang and Helander (1996), in common parlance the meaning can refer to both comfort and discomfort. However, formal definitions of comfort indicate otherwise. According to *Oxford Advanced Learners Dictionary of Current English (*1980), comfort has been defined "as a state of being free from suffering, anxiety, pain; contentment; physical well-being". *Webster’s Dictionary* (1985) defines comfort as a “state or feeling of having relief, encouragement, and enjoyment” (Zhang et al., 1996). Slater (1985) attempted a more scientific definition: “a pleasant state of physiological, psychological and physical harmony between a human being and the environment” (Slater, qtd. in Helander and Zhang, 1996: 377). Hertzberg (1972) in Helander and Zhang (1997) referred to comfort as “absence of discomfort, . . . a state of no awareness at all of a feeling” which in this respect comfort “does not necessarily entail a positive affect’”. In these definitions comfort is conceptualized as a neutral feeling and only two discrete stages are possible: comfort present or comfort absent. The automotive literature provided an operational definition of comfort where the most widely accepted by automotive seating ergonomics research has been"… the absence of

discomfort" (qtd in Reynolds,1993: 100) which had been defined by Hertzberg(1972). The major reason of this approach can be deduced as the necessities surfacing from driving in a constrained position that requires the physiological operation of human beings uninterrupted for long travelling duration and minimising the fatigue. Judic et al. (1993), has stated that comfort has been understood as that which contributes to "well-being" and "ease of use", however the notion of well-being could not be apprehended in a universal and precise manner. In the *International Encyclopedia of Ergonomics and Human Factors* a more recent formal definition regarding automotive interiors, Buti (2001,p.893) indicates comfort is "… the general state of well-being that derives from the reduction or absence of perceived disturbances. It is a passive and sensorial concept, synonymous with convenience". Therefore, a definition based on the notion of discomfort, in most cases treating comfort as the opposite of discomfort setting the two on a bipolar and continuous axis served well in quantification. The generated scales in general present an understanding of a range from extreme comfort through a neutral state to extreme discomfort (Zhang et al,1996). However, Zhang et al. (1996) and Helader and Zhang (1997), based on the empirical evidence provided by their study on office chairs, offered an operational definition where discomfort was based on poor biomechanics and fatigue. On the other hand they proposed that comfort was a separate entity. According to their definition comfort was based on aesthetics, plushness of chair design, a sense of relaxation and relief. The definition stressed that comfort is a multi-faceted construct influenced by several factors, and that it is not merely the opposite of discomfort. Therefore, the debate in the literature skewed on whether there is a prominent difference between comfort and discomfort. Accordingly Looze et al. (2003) proposes that sitting comfort represents a consensually held construct.

However, there has been no widely accepted definition of comfort or sitting comfort. In coherence with the current literature, the common ground in definitions regarding comfort have been indicated by Looze et al. (2003,p. 986) as:

(1) Comfort is a construct of a subjectively-defined personal nature,
(2) Comfort is affected by factors of a various nature (physical, physiological, psychological)
(3) Comfort is a reaction to the environment.

A general point is that researchers in ergonomics literature have come up with descriptions as to what may comfort be and what constitutes the feeling of comfort. However, the definitions have much variation according to the disciplines of the researchers that define it (Jianghong and Long, 1994) and as Vink (2002) has stated, there are various comfort understandings according to the particular area of studies and industries, which encompass the clothing, climate, interiors, automotive and etc. Understandings do or do not encapsulate the "convenience, ease of use" in relation to the product and its usage. Recent studies indicate offering a conceptual model is more effective than establishing a single definition where different factors are portrayed. However, a practical consequence of the preceding research is that comfort and discomfort are different however complementary entities in ergonomics research On top of this the complementation of the two concepts shows a variance in relation to the area of research and object.

2.2.The debate on the nature of comfort – discomfort

With the definitions being the initiation point, in general people have identified the abstract state of comfort in a certain convention, rules of a society mostly. Being either a word, a jot on a scale or a mimic of sighing of a certain relaxation, comfort has been associated with response. Buti (2001) has stated that in order to define ergonomic aspects, it is necessary to compare the reactions of users to what is considered to be the ergonomic characteristics of the product in interaction and define a scale of the quality investigated. Studying models proposed in literature, discussion of methods used to measure feelings and perception is inevitable.

Ergonomics, according to definition means "ergon", work or effort and "nomos", laws or rules. Therefore, the definitions of fundamental terminology should be sought in some other discipline where the investigation is of human nature. This being psychology, referential terms have to be derived from this discipline on human nature. In the *Dictionary Of Psychology* by Raymond J. Corsini (2002) comfort has not been defined however certain terminology surrounding the concept has been defined as follows.

Feeling:

1. An affective or emotional state or an intuitive awareness
2. A tactile or temperature sensation
3. The word feel (affection)

Affect: the emotional feeling tone or mood attached to a thought as well as its external manifestations. An early designation of that aspect of the mind that contains emotions and feelings.

Behaviour: Actions, reactions and interactions in response to external or internal stimuli including objectively observable activities, introspectively observable activities and unconscious processes.

The only formal definition regarding comfort has been the "comfort zone" regarding thermal properties of the environment in relation to human beings, in the dictionary.

Until the study of Zhang et al. (1996), in ergonomics literature as previously mentioned, the concept of comfort/discomfort was measured on a single scale and comfort was mostly treated as lack of discomfort, just like a binary state therefore, the methodologies mostly reflected this type of approach. However, Zhang et al. (1996), focused on the identification of these variables of the causes of comfort and discomfort in a seated workplace. First, in a questionnaire survey, 104 respondents provided descriptors of the feelings they experienced when they felt comfortable (e.g. agreable, at ease, calm) or uncomfortable (e.g. fatigue, cramped, restless). Secondly, to validate these descriptors, another group of 34 participants was asked to rate these descriptors on a 5-points scale, from 'very closely related to comfort/discomfort' to 'not related at all'. After this analysis, 43 descriptors remained: 21 for discomfort and 22 for comfort. Thirdly, a classification analysis was performed, involving multi-dimensional scaling, factor-analysis and cluster-analysis, to statistically identify the factors related to comfort and discomfort. It was concluded that comfort and discomfort are based on independent factors. Feelings of discomfort have been mainly associated with pain, tiredness, soreness and numbness in the study. These feelings were assumed to be imposed by physical constraints and mediated by physical factors like joint angles, tissue pressure and circulation blockage. Comfort, on the other hand, has been associated with feelings of relaxation and well-being.

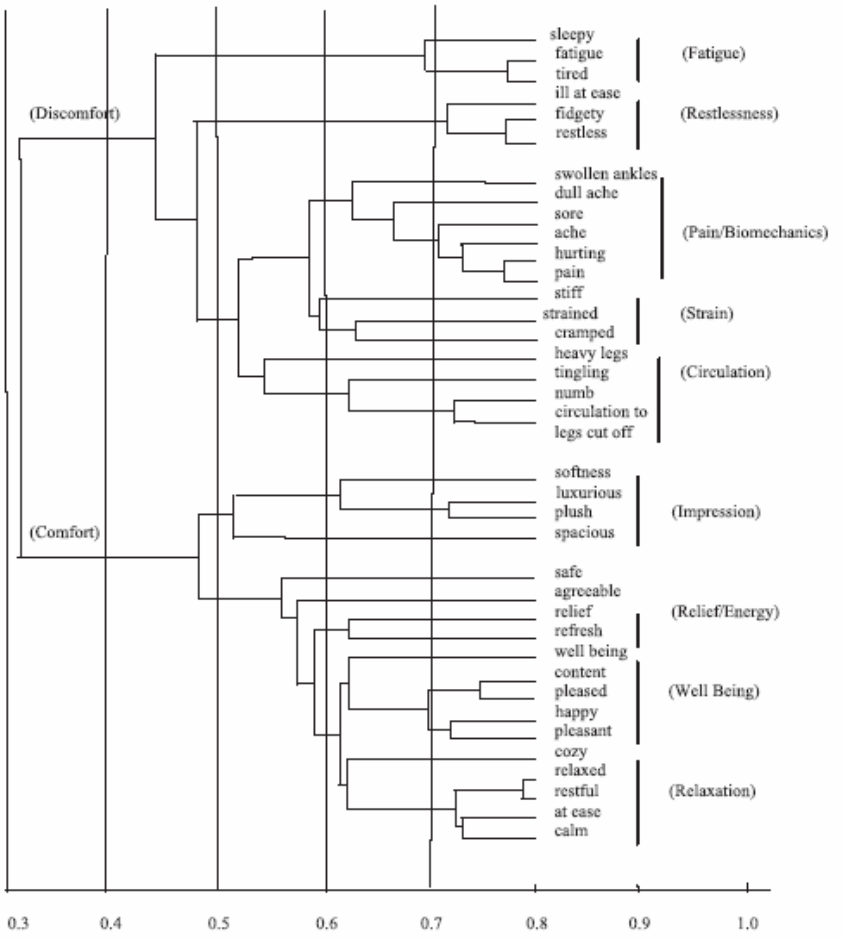

Figure 1. Results of Cluster Analysis (adapted from Zhang *et al.* 1996).

Figure 2.1. Simplified structure of cluster analysis of comfort and discomfort
Note. Reprinted from Identifying Factors of Comfort and Discomfort in Sitting by Zhang L, Helander M.G., Drury C.G., Human Factors,199g,38 (3), Human Factors and Ergonomics Society.

Another very important finding was that the sensation of comfort may be "amplified" by aesthetic design of a chair, where the subject particularly "liked" the chair (Zhang et al.,1996). Particularly the impressions about the chair played a major role in the perception of comfort.

A later study (Helander and Zhang, 1997) involving 20 and 37 subjects respectively, confirmed the factor structure. It was also observed that aesthetic design mattered

with respect to comfort, but not to discomfort. They indicated that, when discomfort factors were present, comfort factors become secondary in the comfort/discomfort perception where discomfort had the dominant effect. From these results they proposed that comfort was a concept in its own right and proposed a conceptual interaction model of discomfort and comfort is illustrated in the figure 2.2.

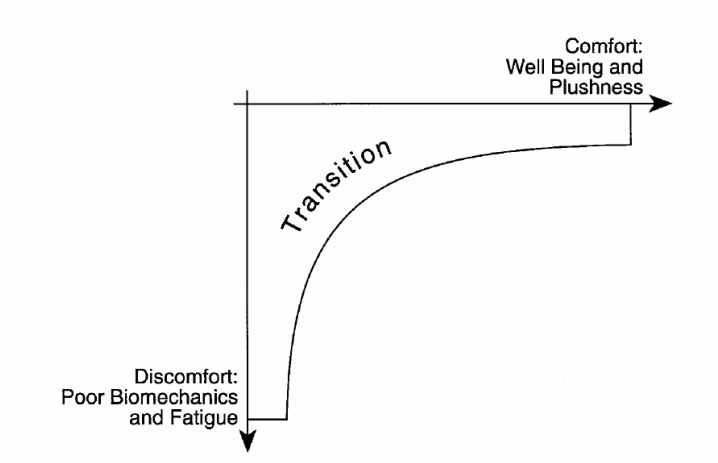

Fig 2.2. Conceptual model of sitting comfort and discomfort.
Note. Reprinted from Field Studies Of Comfort And Discomfort In Sitting. Helander M.G. and Zhang L., Ergonomics,1997,Vol.40. No 9, 895-915), Taylor & Francis.

The model proposed by Zhang et al. (1996) suggests that good biomechanics will not increase the level of comfort, but poor biomechanics may turn comfort into discomfort by degrading the sensation. Also the importance of aesthetic impression was portrayed in the fact that plushness increased the perception of comfort. The field studies carried out by Helander and Zhang (1997), proved that adverse biomechanical conditions was a major player in discomfort, however on top of this, "fatigue" which was shown to be a time dependent aspect of discomfort (independent of seat) was also dominant in the perception. The study also confirmed that the

absence of discomfort, which can be provided by the elimination of physical adverse conditions, did not automatically produce comfort and hence the absence of comfort does not automatically result in discomfort. Therefore, in terms of "sitting" comfort in an office environment, comfort and discomfort were accepted as different entities having different sets of underlying factors and were complementary in a sense that a transition in the perception is possible between the two. These findings in fact were found to resemble the theories of job satisfaction. Another very important conclusion was that Helander and Zhang (1997), also noted certain similarities in their approach with that of Kansei Engineering which uses expressions of customers' feelings as a guide to product. In their study many expressions of feelings related to chair design served the purpose of evaluating chairs.

Looze et al. (2003) carried out a literature survey using the computerized systems analyzed, isolated 21 studies, in which subjective (dis)comfort ratings and objective measures were simultaneously obtained. The intention of the paper was to analyze whether objective measures were related to subjective feelings of comfort or discomfort.

Looze et al. (2003), proposed a theoretical model which embraces three different levels of factors which may affect the perception of discomfort and comfort. The influential factors have been considered under the "context", "seat" and "human" levels, where discomfort has been related with the physical factors (seat) and the physical demands of the task (context) in hand. At the human level, the physical capacity in relation to "physical exposure", "dose" and "response" determines the discomfort felt. According to the model, the exposure to the loading factors in relation to the task, leads to an "internal dose" of the body activities required, leading to "responses" of the body under the loads.

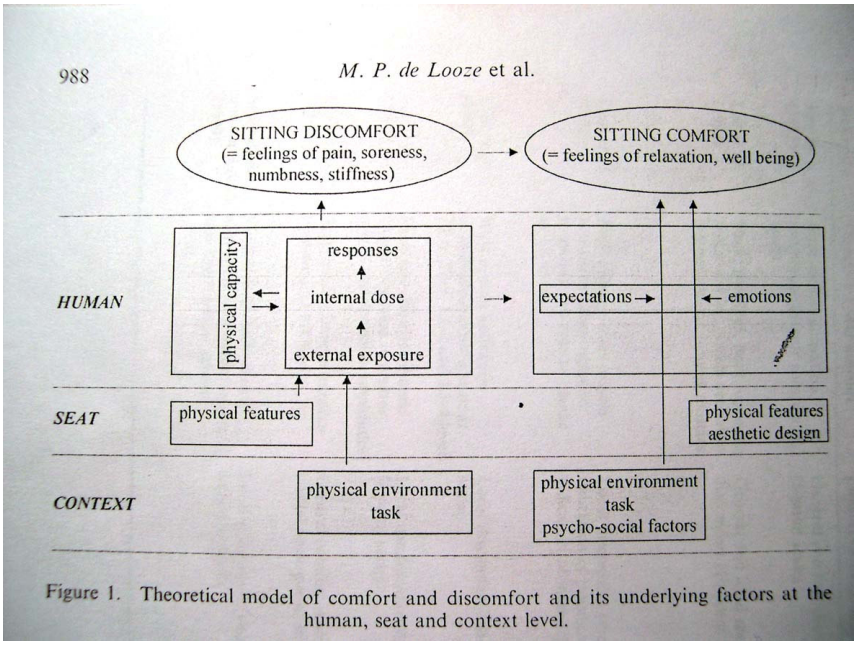

Figure 1. Theoretical model of comfort and discomfort and its underlying factors at the human, seat and context level.

Fig 2.3. Theoretical model of comfort and discomfort and its underlying factors at the human, seat and context level.

Note :Reprinted from Looze M. P., Kuijt-Eversa L.F.M., vanDieen J. "Sitting comfort and discomfort and the relationships with objective measures " . Ergonomics 46 ,(2003): pp 985-997.

The external loads provoke an **internal dose** in terms of muscle activation, internal force, intra-discal pressure, nerve and circulation occlusion, and skin and body temperature rise, provoking further chemical, physiological and biomechanical responses according to the model. Looze et al. (2003) have depicted from which sources of the sensorial mechanisms can the **perception of discomfort** be initiated:

- exterocepsis (stimuli from skin sensors)
- propriocepsis (stimuli from sensors in the muscle spindle, tendons and joints),
- interocepsis (stimuli from internal organ systems)
- nocicepsis (stimuli from pain sensors)

It has been stated that, according to the model proposed, the relationship of objective measures with discomfort has been expected to be stronger than for comfort, as the "response" has been depicted to be more directly associated with discomfort. The right part of the model depicts comfort, such as feelings of relaxation and wellbeing. The influential factors have been presented on a human, seat, and context level. At the context level, not only the physical features are assumed to play a role, but also psycho-social factors like job satisfaction and social support. At the seat level, the aesthetic design of a seat in addition to physical features can affect the feelings of comfort. At human level the influential factors are assumed to be individual expectation and other individual feelings or emotions. However Looze et al. (2003) in his model has not considered the positive effect of comfort acting on the discomforting factors. The affecting mechanisms of discomfort as depicted on the model work only one way. However, in literature the positive effects of emotional and expectation factors have been well depicted to overcome certain negative or discomforting factors. Also the time interaction regarding the factors effecting and affecting has not been depicted in the schematic model, although the dose inherently supposes a time domain of interaction with certain factors.

Based on the model proposed by Looze et al., Vink (2002) has stated that three states of comfort can be distinguished and felt by a human being regarding all the factors. The possible outcomes of this interaction have been proposed as:

- "Discomfort" where the individual is in discomfort, because of the physical disturbances in the environment,
- "No discomfort" in particular where the participant is not aware of any discomfort,

- "Comfort" where the participant experiences noticeably more than expected and feels comfortable.

Vink (2002) has also suggested that a product in itself can never be comfortable. According to his suggestion the user makes the decision whether or not a product is comfortable or leads to discomfort in its usage. It is this dimension that previous experiences, the "history" of the individual and the current "state" of the individual during the interaction plays a significant role in the experience leading to the decision. Vink (2002) has emphasised the importance of external stimuli (input) and the weighing processes in the human proceeding the stimuli. The instantaneous states of arousal or experiences in the past influence these weighing processes. Based on these processes the product produces certain outcomes of feeling. Vink (2002) also underlines that, in reality the elements forming the processes are not separated. However, how the elements relate to each other and what each element contributes to the total experience is hard to define. Therefore, the importance of performing experiments with products in the design phase in an environment as close to the naturalistic setting as possible was suggested. Another very important aspect pointed out by Vink (2002) was the influence of visual input. The first ideas of a product are communicated visually however it can be alluding. A negative evaluation based on the visual information can mislead, expectancies after usage may change to positive.

Helander (2003) also has pointed out a reverse process where the ability of design gimmicks affect comfort perception. Especially the tilt and swivel mechanism such as ‘posture -tilt’, ‘swivel-tilt’, and ‘syncro-tilt’ in office chairs were underlined as not necessarily ergonomic requirements. However, becoming associated with a sense of well-being, they are perceived as convenient or fun, although not improving biomechanics.

Although chair users have agreed on the definition of discomfort and the pain involved in sitting in a bad chair, Helander (2003) has underlined that the comfort or the positive aspects have been difficult to define. The understanding of chair discomfort was easily identified by chair users and was related to the physical constraints imposed by the design of the workstation where factors such as joint angles, tissue pressure, muscle contractions, blood pooling and circulation blockage form the feeling. Especially from the study they observed that, biomechanical discomfort factors increased as a function of time of day where chair design did not seem to matter. Therefore, discomfort was defined as a function of time on task and fatigue.

However, Zhang and Helander (1997) concluded that the proprioceptive senses did not provide the required accuracy in order to discriminate between some design features on different chairs. This was attributed to the fact that the memory trace of the biomechanics and proprioceptive states lasted for only a few seconds more or less. However, if there is a chronic state of discomfort this can be attributed to the cumulative processes leading to a health hazard which has not been mentioned. In their study, users were not particularly sensitive to minor design changes in ergonomic variables; they were simply not perceived. Therefore, Helander (2003) has concluded that more important than ergonomics is aesthetics design and the chair users made great discriminations in terms of aesthetics which were consistent in ratings either high or low. The taste of the individuals was also quite consistent. Helander (2003) has emphasized that ergonomics remains important, and good ergonomics is a precondition for comfort. However, the importance of ergonomics in design of chairs had been exaggerated. If basic ergonomics rules were not violated the significance of comforting factors became more important than discomforting

factors and the need to understand how to measure and predict the emotional value in design—not only of chairs but of all kinds of artifacts that surrounds us was underlined. The major question presented was how such affective variables can be translated into customer requirements which in return will be transformed into physical design parameters.

2.2.1. Objective methods and discomfort in sitting

In the literature of comfort only sitting affords so many so called objective methods of quantification. The most advantageous aspect of objective methods in comparison to subjective methods is that they are less time consuming, require a smaller number of subjects, are less prone to measurement error or bias, and are applicable earlier in the design process (Lee et al. 1993).The most common are **:**

- Posture and movement
- Electromyography
- Pressure distribution
- Spinal load
- Vibration transmission

However, as depicted objective methods that assess comfort are indirect. They measure a physical quantity of something else and can only give an indication of an individual's sitting comfort. Only if correlations between objective measurements and subjective sitting comfort are provided, then do the objective methods form a useful addition to subjective methods. On the other hand which objective method serves best is another debate where Looze et al. (2003) have suggested that pressure distribution appears to be the objective measure with the clearest association with the

subjective ratings. However, Porter et al. (2003) has argued that there was no clear and consistent relationship between subjective ratings of discomfort and the interface pressure readings. It was concluded that the incorporation of pressure measurements besides the rating of the subjective feelings of comfort and discomfort in the process of car seat design, would be valuable. But still, the value is rather limited as indicated by Porter et al. (2003) as they concluded that there is no consistent relationship with the simple quantification of static seat interface pressure data from a variety of individuals, with the assumption that high (or low) pressure values are predictors of reported discomfort during an extended drive. Although they used three cars with static measurement, indicating that there needs to be dynamic measurements for proper analysis, no clear relationship existed between subjective ratings of discomfort and the interface pressure readings selected for cars in their study, also the complications caused in dynamic measurement has a high probability of altering the actual discomfort feeling of the subject. The model proposed by Looze et al. (2003) considers an exposure which internally entails a time scale. However, this has not been explained in detail as the suggested pressure reading method, which does not indicate an aggregate value may not indicate the time dependency for discomfort. Continuous means of recording is needed for proper association. For the other objective variables (posture, movement, muscle activity, spinal load), it is premature to state that measuring these variables would be useful in seat evaluation and design. So the basic bottle neck with objective measures is the correlation which relies on subjective data. The most obvious useful objective data therefore, appears to be geometrical-dimensional data related to task geometry.

Kolich and Taboun (2004) proposed a statistically reliable and valid subjective output overall comfort index which made possible the development of a stepwise,

linear regression model. The input variables included (1) seat interface pressure measurements, (2) participant anthropometry and demographics, and (3) perceptions of seat appearance. They claimed that the link between objective measures and subjective perceptions was established and validated which the model suggestively established human criteria for seat interface pressure parameters. The overall comfort index was shown to reduce the bias thought to plague traditional complete seat comfort ratings and Kolich (2004) identified a source of potential bias which was the respondent's perception of seat appearance. He claimed that the overall comfort index derived from his questionnaire using a separate ranking for seat appearance, can be predicted using automobile seat interface pressure, occupant anthropometry, occupant demographics, and perceptions of automobile seat appearance. Interestingly enough, in this study the scatter plot of overall comfort index vs. appearance rating showed a negative correlation where as the overall comfort index decreases the appearance of the seat becomes more aesthetic. (Appearance rating -0.645, correlation is significant at the 0.01 level (2-tailed). This is highly discrepent as Kolich (2004) refers to aesthetics affecting positively the overall comfort perception where his regression model offers a negative correlation multiplier. Although Kolich (2004) referred to Helander (2003) and proposed that aesthetics is expected to affect comfort index, negative corelation should not be what he anticipated. The most obvious reason for this negative correlation is that, the expectancy of the subject`s comfort from the first impressions of the seat may be deceptive from the functional comfort. Another major problematic area could be the experiment protocol where proper observation and rating about the seat may not have been established as Kolich's questionnaire is more oriented for pressure data acquisition. Therefore, only

one item of 5 ranks for perception of comfort impressions is bound to be not sufficient for any thorough investigation.

2.2.2. Comfort and Hand tools

Recent studies conducted by Kuijt-Evers et al. (2004) have contributed to the discussion of the nature of comfort in their study conducted with hand tools where descriptors for both pliers and screw drivers were used. In contrast to the suggestions of Zhang et al. (1996), they proposed that the nature of hand tool comfort afforded being two opposites on a continuous scale, because they found that the same descriptors underlie comfort and discomfort. Therefore, they decided not to treat comfort and discomfort as different constructs, but to look at comfort and discomfort as one general concept. Descriptors of discomfort such as muscle cramp, sore muscles, blisters, etc. were also found to relate to comfort where they proposed that this was due to the difference between the nature of seats and hand tools. Hence, they proposed that the difference between comfort and discomfort depends on the kind of product used. The major reason for this was shown as the discomfort factors present in hand tools. Comfort was dominated by discomfort inherent in function. Also they indicated that functionality was most related to comfort when hand tools were considered, followed by physical interaction and appearance. Based on the Primary Componet Analysis (PCA) method used, the factor classification for comfort in using hand tools for this study, consisted of three groups: The first factor contained descriptors as reliable, functional, task performance, and ease in use, safe, etc. which were labeled as functionality. The second to the fifth factor corresponded to the physical interaction between user and hand tool: posture and muscles (factor 2), irritation and pain of hand and fingers (factor 3), irritation of hand surface (factor 4),

and handle characteristics (factor 5).The sixth factor was about the aesthetics and contained descriptors such as professional looks, styling, nice colour, and solid looks. Descriptors of appearance were slightly or not at all related to comfort in using hand tools where the results were in contradiction with the results of Zhang et al. (1996) who found that aesthetics is an important underlying factor of comfort in sitting. Therefore, they proposed that the relevance of aesthetic factors depended on the kind of product and the task which is performed with the product. As a result, for this study the actual thought of comfort may have shifted to absence or reduction of discomfort.

Kuijt-Evers et al. (2004) have stated some similarities between comfort research and product satisfaction research. They proposed that evaluation of comfort/discomfort was mostly based on cognitive judgments. Referring to Mano and Oliver (1993), they stated that in product satisfaction theories it was assumed that cognitive judgment consists of two major dimensions:

(1) Utilitarian performance; where the product was perceived as performing a useful function

(2) Hedonic performance; where the product was valued for its intrinsically pleasing properties.

With a follow up study Kuijt-Evers et al. (2005) provided the descriptors and the factors (groups of descriptors) that predict the comfort in hand tool use as well as the extent to which they were able to predict it. In this study only screw drivers (Philips) were evaluated. The descriptors of the Comfort Questionnaire developed for Hand tools (CQH) was used based on the results of a previous study. Expected comfort, overall comfort and discomfort (local parts discomfort, LPD) were measured where LPD was measured using a detailed hand-wrist map, with 23 regions, and an arm

map, which consisted of two regions. The ratings of the descriptors were correlated with the expected comfort at first sight, the overall comfort score after short time use and the lnLPD (logarithmic). Descriptor ratings were not independent as one subject rated these variables four times each (i.e. for each screwdriver). After that principal components analysis with varimax rotation was performed to reduce the independent variables. The descriptors were classified into factors. Multiple regression (forward selection procedure) was used to identify which of the descriptors were the predictors of: 1) expected comfort at first sight; 2) overall comfort after short time use; and 3) lnLPD. After this procedure which of the descriptors predicted expected comfort at first sight, overall comfort after short time use and discomfort were determined in the study. Accordingly, comfort at first sight was predicted heavily from aesthetics, partly from functionality and physical interaction (the most related descriptor was found to be "Has a professional look"). Comfort after short time use was predicted from functionality and physical interaction, adverse body effects and partly aesthetics (i.e. "Easy to use", "Has a comfortable-feeling handle", "Needs low hand grip force supply", "Is functional", "Causes cramped muscles"). Discomfort (lnLPD) on the other hand was predicted from adverse body effects only (i.e. "Causes cramped muscles", "Causes pressure on the hand").

It was concluded from these results that comfort and discomfort in using hand tools have partly the same underlying factors: discomfort feelings also affect the comfort experience. Another major finding was that discomfort in hand tool use determined the comfort experience, whereas discomfort does not influence comfort in sitting. As a result , it was interpreted that comfort in hand tools can partly be predicted from adverse body effects, which determine discomfort, but the best predictors of comfort were descriptors of functionality and physical interaction. Aesthetics has been

denoted as especially important for conjuring the expected comfort by the user. Especially expected comfort was related to the descriptors of "Has a professional look" "Has a nice-feeling handle" "Fits the hand" with a significance of $p<0.01$ (Standardized regression coefficients, beta).

'Professional looks' of a hand tool was the sole affecter of expected comfort. This implied that professional looks is important in product-buying decisions, although it has been shown that it plays a minor role in comfort after short time use. Aesthetics has been denoted as a discriminating factor for consumers as has Helander (2003) noted. Another specific point indicated is that when a hand tool is held for a period of just a few seconds, tactile information was used to estimate the comfort apart from visual information. This is in concurrence with the senses where tactile information precedes and proceeds the information about objects. Another very important finding was that not only the kind of hand tool, but also the properties of one of the evaluated hand tools do influence the prediction model. This means that the comfort feeling of a product is oriented around the particular product which will show differences according to the particular function place and use in our lives. Time domain of the comfort was once more emphasized in this study. Aesthetic impression faded once the tool was in use where functional and discomforting factors claimed dominance over the comfort feeling. However this does not mean that owning an aesthetic tool does not enforce the feeling of comfort if the function serves well.

2.2.3. Kansei Engineering

The feeling analysis and studies of translation of consumers' psychological feelings into perceptual design elements has been named Kansei engineering(KE), also named as "emotional usability" where recent comfort studies have become analogous

in terms of investigation methods. Kansei is a Japanese word that corresponds to feeling or impression perception of products (Ishihara et al. 1997). Kansei engineering/kansei ergonomics has been defined as ‘‘translating the customer’s kansei into the product design domain’’. Kansei engineering or Kansei ergonomics was founded at Hiroshima University about 30 years ago (Nagamachi, 2002). Kansei engineering supports product designers by providing relations among customers' feelings and corresponding designs. This technique involves determining which sensory attributes elicit particular subjective responses from people, and then designing a product using the attributes which elicit the desired responses. The automotive industry (Mitsubishi, Mazda, Toyota, Honda, Ford, Hyundai, Delphi Automotive Systems) has been using kansei engineering for some time.

Kansei is regarded as a set of many feelings, rather than a single feeling. The idea has been derived from Osgood et al. (1957) and his colleagues' works in the 1950s and early 1960s. Kansei engineering uses Semantic Differential (SD) method for modeling semantic space which shows relations between the sample and meanings of typical adjective words. The semantic differential was developed by Osgood et al. (1957) as a measurement technique to assess affective meaning. It has been declared that for quantitative analyzing method of meanings, especially for affective meanings in evaluation of designs of products, and for analyzing semantic structures SD the most powerful tool to this day (Nagamachi, 1991, 1995). The semantic differential method is composed of a procedure, where the subject marks a sample of adjective antonym pairs placed on a continuum. Then, the Kansei structure is analysed by principal component analysis (PCA). PCA is used to transform an original set of correlated variables into a new set of uncorrelated variables, which are linear

composites of the original variables. Therefore, PCA summarizes most of the variation in a multivariate system in fewer variables.

As a result, Ishihara et al. (1997) have described the standard procedure of Kansei engineering as follows:

(1) Selection of adjective words for expressing Kansei on the products,

(2) Kansei Experiment: Evaluation of the product samples using a semantic differential method (SD) scale questionnaire,

(3) Multivariate analysis of evaluation data. The evaluation is often analyzed by PCA and Hayashi's Quantification Theory Type I.

(4) Development of Kansei engineering expert systems where obtained relations among components' design, feature and semantic structure are built into inference rules.

It has been stated that the structure of Kansei varies by the sort of products. Kansei structures of car interior design clearly differ from that of garment design. The constraints to products (e.g., functions, size, purpose) must relate specifically to the product design.

Nakada (1997) has proposed a model that portrays the trends when seeking specific Kansei for qualities in earth moving machinery. It has been argued that comfort, cleanliness and job satisfaction have overtaken salary as a primary labour value. Furthermore, he has proposed that human beings acquire 80% of their information through their sense of sight which has great impact on impression also. Nakada (1997) has stated that Kansei values are developed through a series of steps vis – a vis the object observed, the desire to be close (sense of sight), the desire to touch. the desire to move, the senses of hearing and equilibrium. Sight plays an important role of primary stimulus.

Another very important statement by Nakada (1997) was that, in terms of design Kansei values play an important role in addition to mere appearance, creating an image built both on what people see and what they experience , which carries people from “what looks good” to “what looks good to use”.

If the user’s target is a passenger car, all Kansei concerning the exterior, interior, engine, etc. can be implemented in those designs. A study by Tanoue et al. (1997) dealt with the interior image of particularly roominess and oppressiveness conducted through Kansei engineering and the comfortableness diagnostic system was introduced. Kansei engineering type I in this interior image experimental investigation, the details of Kansei space , roomy and oppressive feelings were studied and evaluated by factor analysis on a 5 level SD scale involving 20 1000 cc to 2000 cc passenger cars, 41 panelists and 100 adjective words. The scale constituted from “felt significantly” to “felt nothing”. Analysis with quantitative theory type I, the nature of design element items producing high partial correlations with perceived roominess and the oppressiveness feelings, color and shape also regarding a cars geometrical dimensions certain angles imposing the feelings were described. Optimum dimensions were proposed in this study.

2.2.3.1. Motivation Theory and Relevance to Comfort Concept Models

Vink (2002) has stated that comfort can be felt when more is experienced than expected in relevance to the Hertzberg et al’s. framework of the motivation theory. In this frame work satisfaction and dissatisfaction were affected by certain factors at the work place. Hertzberg et al. (1993), proposed hygiene factors which were physical. According to Herzberg et al. (1993), these cannot motivate employees but can minimize dissatisfaction if handled properly, it can only avoid dissatisfaction.

Dissatisfaction factors were mainly related to salary, company policies, working conditions and etc.(Vink, 2002). These concerned the environment and the working conditions, other motivation factors which are associated with work itself. However, satisfaction due to motivating factors was related to fulfilment of individual's needs for meaning and personal growth. These were achievement, recognition, advancement, which created satisfaction by fulfilling the individual's needs for meaning and personal growth. It has been argued that, in comfort a similar division can be made.

Helander (2003) suggested that comfort studies also possessed analogies with Maslow's theory.

The pyramid of needs according to Maslow was defined from bottom to top in this order:

- Biological and physiological needs
- Safety needs
- Belongingness and love needs
- Esteem needs
- Cognitive needs
- Aesthetic needs
- Self actualization
- Transcendence

The pyramid's structure depends on the fact that, the lower block of needs under the higher needs have to be fulfilled first. A very important aspect has been indicated by Postrel (2004) that Maslow's hierarchy did not inherently suggest that higher needs represented unimportant luxuries. It has been argued that he saw them as essential expressions of human instincts. It has been emphasised that aesthetics was not a luxury that human beings care about when wealthy. Although the schematic pyramid

proposed that experiential and aesthetic needs can be classified as higher order needs, it was proposed that each layer did not depend on completely satisfying the need under it. A proof of this was simply stated by the following lines in Postrel (2004) "Given a modicum of stability and sustenance people always enriched the look and feel of their lives through personal adornment and decorated objects" (33). Therefore, aesthetics can be seen as a universal human desire. Hence, the look and feel was suggested to be more likely to determine the value of a particular object product when considering possession and usage.

Just as the previous studies suggest, visual communication of products for human beings as a society of interacting mammals has particular importance for the comfort of the human animal. Aesthetics does not only suggest beauty but also function. The expectancy of a good functioning or fit mechanism also suggests a good look where comfort will depend on both. Therefore, in between the suggested layers of needs or otherwise factors shortcuts between different layers can be suggested for any model of comfort.

2.3. Conclusion on the conceptual discussion of comfort and discomfort

As Brant (1995) has depicted in the main roads of human phenomenology two worlds are concise. Matter on one hand and Idea on the other. The material realm affords presentation concretization where from the ideal realm representation concretization occurs. The world of concrete realm of solid objects or bodies which are subject to sensory division as Brant (1995) has put it; as close and distant sensation. On one hand touch and taste on one pole for close, material and **causal** where on the other smell, hearing and vision being **ideal,** final and distant.

Comfort seems to be an object and time related state of a human being. A state is a more or less conjuncture of forces, an organisation of descriptors of feelings. The causal and ideal related sensations form this state. An object affords a certain number of descriptors in relation to the occupied space, time and function in a human beings life. Descriptors are verbalized feelings regarding the initiation of stimuli from sensors and the processes following this initiation. It is a given fact that verbal descriptions are conveyed with certain conventions of language and thought. However we assume that the physiological and psychological processes underneath are well established for all humanity. Comfort is a gestalt that is a particular organisation of descriptors, an entity of feelings. Most of all the entity of comfort and discomfort has descriptors conjured via visually perceptive information as well. Discomfort is also an organisational entity of factors acting on the human organism however one descriptor in this organisation may also be enough to produce discomfort and degrade the comfort feelings. The two feelings of comfort and discomfort are both three dimensional planes, topologies in their own sense. They may be linearly laminated one on top of another for one product however may not be for another. Therefore, this layered perception of the topology state of comfort may or may not be in concordance with the *superposition principle* for the space geometries formed by comforting and discomforting factors. The superposition principle tells that the resultant loading at any point of two or more descriptors which are in the same medium equals the algebraic sum of the individual loadings. As suggested by Kuijt-Evers et al. (2005) discomfort mainly determined the comfort feeling in hand tools where comfort and discomfort were placed in the same continuum as a result. This result was due to the finding of same factors underlying the perception of comfort and discomfort. However, this may not be the case for all

objects as Zhang and Helander (1996) proposed for office chairs. If the discomforting factors are eliminated (reduced to a 2D plane) then comforting factors are felt (3D topology of factors). For a clearer understanding, figure 2.5 displays a descriptors loading in a comfort plane and a discomfort plane.

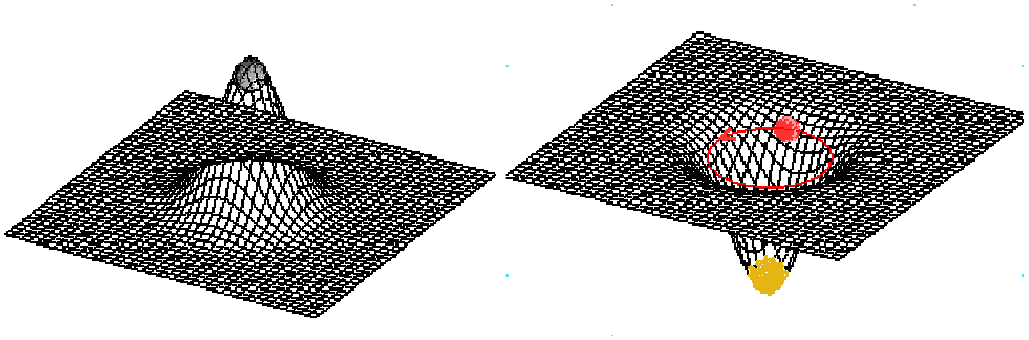

Figure 2.4 On the left a comfort descriptor action on the comfort plane. On the right a discomfort factor acting on the discomfort plane.

The descriptors weights act on the planes bending the space geometry for the two feelings. As Helander (2003) suggested the transition from one topology to another may be hyperbolic for office chairs. When discomfort factors are more dominant (heavy) comfort feeling can not be felt. As displayed in the figure 2.4 the feeling (red particle) is attracted by the dominating discomfort factors i.e. fatigue. This type of description is similar to a vector field consisting of a collection of points in space, called the domain.

The space or the function is continuous, however the vector fields are not. Therefore comfort and discomfort can be regarded as domains where the descriptors act as objects imposing gravitational fields on these domains. These descriptors curve the

space according to their masses. In the midway the gravitational fields may cancel each other. Far from the mass object the space is perfectly flat which in our case can be named as homeostasis if we are describing discomfort domain. The universe of comfort has much analogy with the theory of Einsteinian relativity, where space and time themselves expand or contract according to masses, and the dynamic theory where the dynamic distributions are affective on the organisation. Particular planets of factors bend the "comfort" space and time plane with regard to the weighing (factor loading) of gravitational fields. Thereby feelings may dwell on a particular factor when using the tool but not when observing it. Also the construct of planes where the stratification of certain sensations will affect directly such as short cuts (worm holes) between two universes like comfort and discomfort. The interactions of object-object, ego–object and environment-object, environment-ego are all the determining factors which organises the comfort domain in the mental space and time. Discomfort domain on the other hand may be regarded as more direct due to the nature of sensation felt.

In relation to the conceptualisation of comfort and discomfort in this space geometry sense, the time domain of the perceptions gains importance as depicted by the studies in literature. As Vink (2002) had suggested the history plays an important role in comfort perception. This may be attributed to the fact that when a particular topology of comfort is experienced, the memory traces of the topology are expected to be provided by the same category of product in experience. If not the result is not comfort as the former template of the topology does not fit the current feeling of comfort. When more is experienced than the former, a new standard of comfort is set. Also for the expectations of comfort proposed by Looze et al. (2003), Kuijt-Evers et al. (2004), Kuijt-Evers et al. (2005) the same can be suggested. On top of

history the promise of comfort via visual communication of the product affords another template of comfort topology. If the toplogy is sattisfied in experience than comfort feeling is fulfilled and vice versa. Biases also act in the same mechanism of template topology.

In this interaction the time domain is important as pointed out by all studies. The human body is susceptible to discomfort factors given a period of time especially considering a task carried out by the product. The transformation of comfort to discomfort domain is also a function of time. Especially as proposed by Zhang and Helander (1996) the fatigue component of discomfort domain is dependent on time where fatigue will increase with time eventually considering a task. A consequence of this also can be explained theoretically that the curvature of space time (discomfort) by matter (fatigue) therefore not only stretches or shrinks distances, depending on their direction with respect to the gravitational field (fatigue loading), but also appears to slow down the flow of time. This effect is called gravitational time dilation. Thereby the more fatigue is built up the more it is felt and the time flow is slowed down (if fatigue was to build up endlessly it would form a black hole where mass is infinite and time is at an end which does not pass, a singularity point).

However, basically time spent with comforting factors will pamper the comfort sensation where as time spent with discomforting factors will hamper the comfort feeling. Too much exposure to discomforting factors eventually will turn the whole sensations into feeling discomfort.

Emotions in this space geometry have a vital role. Instantaneous state of a human being may amplify or dampen the feeling of comfort or discomfort according to the state of the individual. An emotion may be so strong that it can fluctuate or manipulate the whole organizational geometry accordingly.

In this state of relations of comfort domain and discomfort domain design of products brings around an intervention. An intervention has been defined as a planned change in this conjuncture of forces, a modification of the relationship between involved forces (Brant, 1995). Thereby recognising the potential sources of factors effecting and affecting the domains enables us to redefine the space geometries of comfort and discomfort. As discomforting factors are more or less consistent throughout humans (Helander 2003) and can be elimiated by ergonomics interventions, the focus can be shifted to comforting factors. Developing the "human sensibilities" of materials and the designs, adding sensory emotional appeal to ordinary functions opens up new horizons for comfort feeling. New sensorial applications can indeed establish new comfort topologies.

2.3.1. Practical projections for automobile seat comfort

In coherence with the existing literature and human nature it can be suggested that the current state of ergonomics afford two interdependent, time sequenced, cyclic, co-existing operational definition for automobile seat comfort:

- **Pre-seated visually perceived seat comfort**; an intuition due to the visual inspection that the seat will offer a pleasant state of physiological, psychological and physical harmony for the human being and the environment.
- **Seated comfort**; "absence of discomfort" that does not entail a positive effect regarding emotional or mental state. This definition should be coincident with the occupant's empirical perception of being at ease (Reynolds,1993), and should be able to address the complete physically functional needs of the occupant, circulation, pressure distribution, biomechanics, strain, fatigue

retardation and habitability (in relation to geometry imposed by the car) with other physiological and anthropometrical issues. Homeostasis of the human body the sympathetic and para- sympathetic nervous systems are vital for this definition. However, if the above conditions are supplied, the satisfactory compliance of the conditions with the previous intuition leads to positive affect.

A model can be devised to present the complicated and cyclic nature of the automobile seat comfort for practical purposes displayed in figure 2.5, where the pre-seated domain has been adopted from the model proposed by Crilly et al. (2004).

The **pre-seated comfort** considering a car seat is the abstract comfort mainly initiated by the impressions of previous experiences and instantaneous inspection. Leaving a continuing trace of the impression and feeling, it has a cyclic nature of being experienced and enforced by positive experience of physiological quality. The pre- seated seat comfort belongs to the **perceived habitability** of the interior. As Buti (2001) in the *International Encyclopedia of Ergonomics and Human Factors* has defined the perception of space as a determining factor in the general sensation of comfort and it is provided by "the complex relation of the physical dimensions of the inside of the vehicle to the perception of that which is external to the vehicle (by means of windows and windscreen) and to ease and liberty of movement inside the vehicle and the image of forms and colors create." (893) On top of this definition the **comfort of vision** was defined as "… the quality of forms and colors". (894)

The two definitions act in the pre-seated time domain of comfort where it is extended to the *seated comfort* time domain. The memory traces of the initial visual inspection by the occupant proceeds to what is felt.

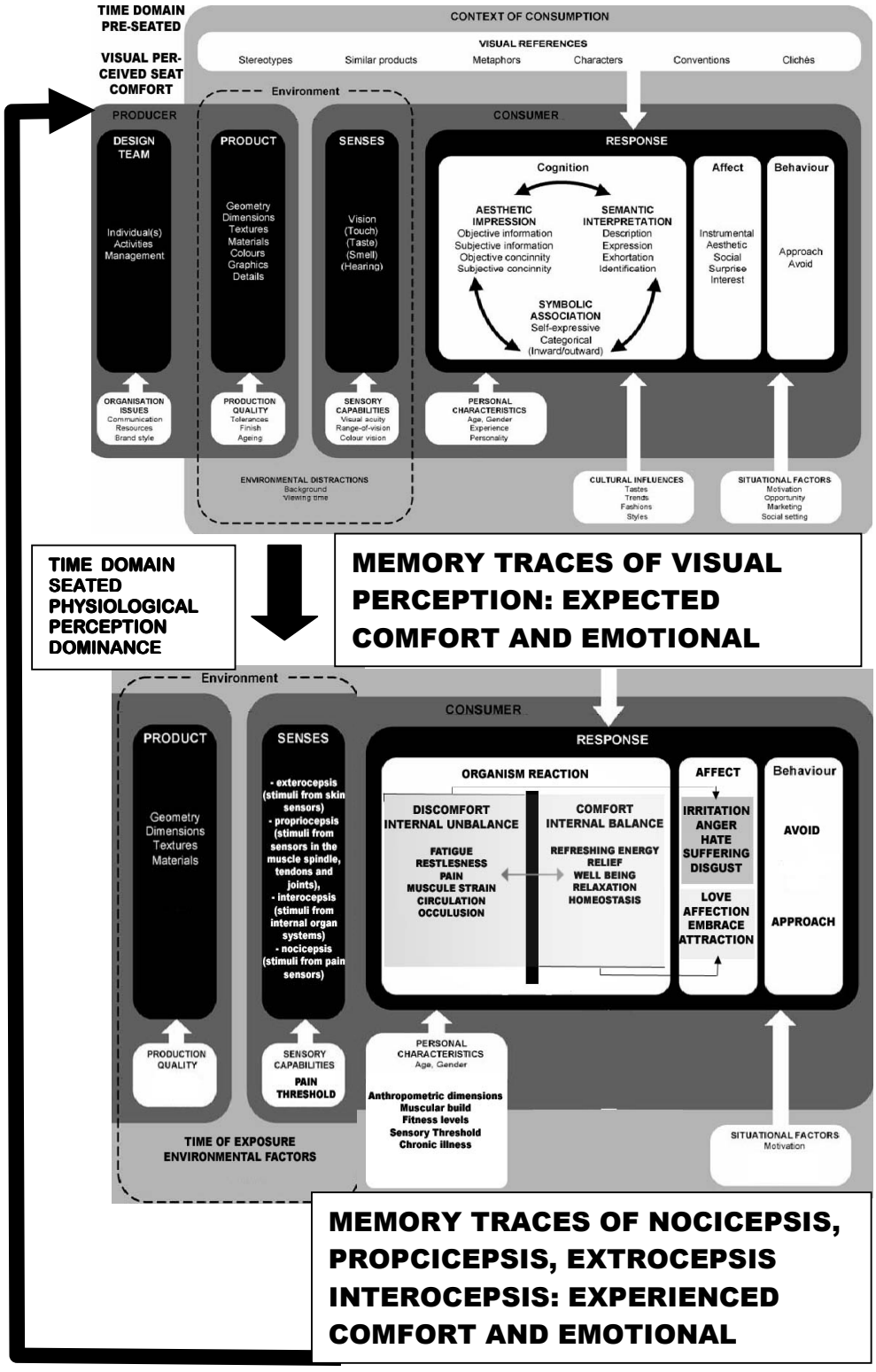

Figure 2.5 The practical model depicting the response and the cyclic nature of the automobile seat comfort perception.

Expectations and emotions with semantic functions can nurture this abstract state where physical appearance is the major tool of communication.

The topology of comfort may be affected by cultural and natural necessities in the abstraction where physiological necessities dictate the physical seat geometry. However, how much of “taste” and “preference” is related to comfort is another matter. If comfort is more about taste and preference, gender issues will gain importance. Porter et al. (2003) has argued that it is unlikely that car seats will be designed to reflect gender differences. Although no difference between male and female has been found in literature currently on gender difference due to the methods used; on the basis of emotions, expectations and aesthetics of comfort there is bound to be a difference. However, the expectation and emotional domain relies more on intuition than experience. The brand name and the created loyalty play a major part in this pre-psychological domain. As Helander (2003) suggested maybe without knowingly, customers may favor aesthetics at the expense of ergonomics, which can also hold true for automobile seats. It was difficult for chair users to distinguish between ergonomic qualities between chairs anyway. Comfort factors: plushness, aesthetics, relaxation and feeling at ease—were highly important, as they had produced significant differences between chairs, which were perceived by customers and had clear implications for design, therefore suggested that more research was needed to understand the conformity of taste. Therefore, the pre-seated time domain needs the investigation of visual domain design in relevance to comfort feelings and factors of comfort.The studies until recently have been reluctant to analyze the emotional influence of comfort on seated comfort. Emotions and feelings depended on the intuition of designers rather than studied and thoroughly analyzed scientific

statements. Kansei engineering has been the most dominant field in this aspect however very little exists in terms of seat comfort.

Seated comfort refers to most physical and physiological challenges (considering the seat only). The experiential value of the seat is embedded in the physics of sitting during the period. The expectation that discomfort is more closely related to objective physical measures as compared to comfort is due to the fact that physiological responses are more direct and have less interference from bias. Discomforting factors appear to be more universal than comforting factors. If antropometric, physical accommodation (5^{th} to 95^{th} percentile) and biomechanical aspects of vehicle seating packages are satisfactory then time dependency of comfort surfaces (Park et al. 1998). It has been well established by Gyi and Porter (1999). 15 minutes has been accepted appropriate for assessment of showroom comfort and 30 minutes represents a short test drive. However, if a long extended drive has to be assessed, at least 2.5 hours of test duration has been proposed and at 30-minute intervals repeated assessment of the discomfort levels has been foreseen. Therefore the dynamic nature of an automobile seat comfort has to be accounted during travel if homeostasis of the human body in the particular posture in terms of circulation and other environmental factors as presented in the model. These will be accounted by material properties and the active-functions of a seat. After the duration of the ride, memory traces of experienced comfort due to nocicepsis, propcicepsis, extrocepsis and introcepsis will prevail to shape the correlations of expectations with visual elements of the seat.

There is no doubt that good ergonomics is a precondition for comfort. However, comfort feeling of a car seat design lies in a combination of good ergonomics and good aesthetics. With the abundance of ergonomic guidelines regarding seat comfort

(will be investigated in the following chapter) the need to understand how to measure and predict the emotional value in design has surfaced. As Kansei approach dictates, psychological comfort will proceed physiological comfort (Nakada 1977). When discomfort factors are present, a car seat can not afford comfort just by a nice appearance. Discomfort factors in car seats must be avoided and reduced by optimization of the functionality and physical interaction. Only when this is accomplished on top of this appearance may contribute to comfort in usage. Aesthetics of interior design and seat design in buying decisions or in choosing between automobiles of the same segment with common functionality and physical interaction may become important. A car seat roughly speaking may entail a comfort domain between a pliers and an office seat, in relevance to function and aesthetics. We can interpolate or extrapolate according to the concept where it lies.

In relation to this model the enhancement of comfort can only occur with appropriate methods which assess and develop the "human sensibilities" of materials, and the designs. These in the scope of a designer can be summarised as dimensions, shapes, aesthetics and the tactile feeling of the seats and the interior. Therefore, the visual domain design regarding comfort should be dwelled upon and the factors affecting the expectations and emotions of users be studied.

CHAPTER 3

ERGONOMICS GUIDELINES FOR SEATED COMFORT: PHYSIOLOGICAL COMFORT

3.1. Seated Operation and Sitting as an Activity

For all activities, in order to carry out the tasks required by the nature of the activity, humans adopt postures. Three main postures can be directly identified, due to the highest frequency of occurrence, from our own. Lying, sitting and standing. In terms of physical effort (heart rate, oxygen consumption), lying has been stated to be the least strenuous posture however it has been also pointed to be the least suited for performing physical work. The necessity of using hands, arms and feet for physical work suggests lying is unfavourable (Kroemer et al,1991). The standing posture on the other hand provides freedom for arm and hand usage for performing physical work, and the positioning of the body via leg movement for better acquaintance with the necessities of the task in hand (providing support and stability). However the standing position requires more energy and muscle activity relative to other postures. Sitting has been recognised to be in between lying and standing, as the body is supported partially while it is still suitable for performing work with limbs. In comparison to standing the posture it is less energy consuming, and frees usage of hands, arms and feet for operation (pedals). However the ability to deliver an adequate force for performing an operation is harder than in standing, being unable to stabilise the force and the direction of operation via the legs and feet if not supplied with adequate support. Therefore anthropometric**,** biomechanical and

physiological consequences of sitting operation are of prime importance for seat design.

3.1.1 Biomechanical and Physiological aspects of seated operation.

Seated in an automobile, the task of driving demands a visual field and a number of forces to be applied to objects such as the steering wheel, the pedals, the clutch etc., which are generated internally by the body and transmitted through the body's hard and soft tissues, requiring adequate support by the seat. During the appliance of these forces, the body structures and the supporting structures supplied undergo different processes due to the forces acting. Stated by Reynolds (1993), in an automobile the seated driver's body weight is supported by the seat cushion, back in major and the floor board partially. The weight is transferred to the seat by a particular posture (Judic et al, 1993; Reed et al,2000). In this complex interaction of variables, the seat design characteristics also play a role in the driver's adoption of an operative posture, which assist the individual and maintain its saneness.

However, first of all, due to the nature of the human body (physiological) there are common processes and necessities, independent of other parameters. Debates on sitting advocates that, the human body has neither biomechanically nor physiologically evolved to neither sit nor stand in a fixed position, especially for long duration (Grieco, qtd in Kroemer et al., 1991). In the 19th century, "sitting upright" had been accepted as "healthy" and "normal" sitting position due to the resemblance of the posture of the upper body especially in the standing position (Kroemer et al, 1991). This can be particularly true if the body is not supported by anything but a seat pan (back, arm rests) and rather neutral (without a major task) posture. However when the arms and head deviate from this centric loading pattern, obviously the

moments due to the extended arms, without support will lead to different loads and require some sort of balance. Simply in an upright posture, the trunk and the neck for the spine are straight frontal plane and an S-curve in the sagittal plane. The series of curves adopted by the spinal column have been denoted as kyphosis for the thoracic area and lordotic for the cervical and lumbar regions.

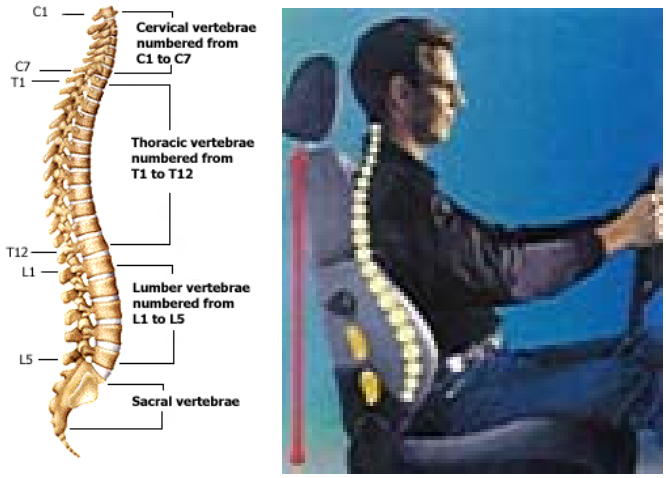

Figure 3.1. The series of curves adopted by the spinal column denoted as kyphosis for the thoracic area and lordotic for the cervical and lumbar regions.

Ref. http://www.steeringdevelopments.co.uk/Seating/spine.jpg (03.10.2006)

If further analysed the spine consists of 24 vertebrae (7cervical,12 thoracic,5 lumbar) and the sacrum with the coccyx. Through the complex nature of the vertebrate held together with in cartilaginous joints of different two kinds, which are fibro-cartilage disks between the vertebrae, and synovial facet joints resident in the two protroubences extending posterior-superiorly (Kroemer et al,1991). Via these structures the spine transfers forces and bending moments, torsion (twisting moments) from head and shoulder bones to the pelvis. The spinal column structure

withstands the compressive axial forces when the body is stabilised by the muscles (erector spinae) running between the pelvis and shoulder areas, which can only contract to restore the posture desired. On top of these static conditions, under dynamic conditions the spine acts as a shock absorber with the cushioning effect of the "intervertebral discs", being exposed to vibrations and impacts transmitted from the pelvis (Pywell,1993).

In sitting, the pelvis (iliac spine) is loaded by the forces and moments acting on the spine. The pelvis, due to the anatomical nature of the bone formation, transmits these forces as pressure distributions via the ischial tuberosities and the buttock (gluteus maximus) muscles and other associated soft and hard tissues to the seat interface. (Pywell,1993). However, stated by Kroemer et al. (1991), the ischial tuberosities also act as "fulcra" which leads to rearward pelvic rotation, especially if seated on a hard surface. As various tissues and muscles connect the pelvis, the lower spine and the lower trunk, this rotation in return flattens the lordotic shape of the spine forcing it out of the "normal" position. According to Kroemer et al (1991), this was pointed out by orthopaedists and physiologist as a "highly undesirable" condition. Another role player in the rotation has been stated as the tissues connecting the hip and the knee joints, where the flexibility and the length of the muscles and other tissues are known to affect the sitting posture and spine curvature. In major, the hamstrings, which originate on the bottom of the pelvis and inserts below the knee on the lower leg, pull on the bottom of the pelvis and restrain the movement of the pelvis thereby acting up on the lower spine (Hubbard et al., 1993).

The physiological consequence of sitting is that, the soft tissues (buttock areas) under the ischial tuberosities are compressed under the weight of the upper body. Although the pressure distribution varies according to the supporting surface, on a flat surface

it has been stated that the pressure concentrations are the highest right under the tuberosities and gradually decreases towards the outer regions in a radiating manner (Reynolds,1993). The thighs also act in distribution of the weight in a considerable manner. Beyond compression, in a seated position the tissues are also subjected to shear, bending moments and tension according to the posture adopted (Pywell, 1993).

The theories of discomforting mechanisms of seating have been based on the acceptance of these "healthy" sitting configuration or organisation of the structures and the processes involved. From these fundamental issues a general basis has been formed on whether "ergonomic" supports have been deduced to help the body maintain its physiological and psychological saneness.

In terms of discomfort mechanisms, biomechanical stress due to posture acting on the body, static muscle activity required to hold the body in a near stable position, lower back pain (LBP) due to repetitive trauma and pressure concentrations on various supporting tissues of the body has been pointed out by many researchers.

In general these various mechanisms can be simplified as follows.

- The postural stress experienced have been attributed to maintaining the posture (described by the joint angles which is adopted by each individual in the neck, chest, pelvis legs, ankles, elbows, vertebra … etc.) over a prolonged time period.
- The "increased muscle activity" has been stated as when the body is not properly supported, several muscle groups acting together to restore stability and cause static muscle loading. In the long term these have been stated to cause fatigue and pain. These have been attributed to poor seat design and package conditions.(Troup; qtd in Reynolds,1993)

- Lower back pain (LBP), however reasons and causes remain unclear, can be sustained in long term due to the improper sitting posture combined (such as slumped posture leading to high disc pressures and suppressing the anterior of the discs) with repetitive loading. These eventually can lead to herniated discs, in return pressing on the spinal nerves. Exposure to repetitive vibrations, impacts and shock also form a part of the problem (Troup; qtd. in Reynolds,1993). Another mechanism stated for (LBP), has been the much faster deterioration of intervertebral discs that are not feed by any circulatory system due to postural fixity, where the vital nutrients and metabolites are transported by activity and posture change.
- The consequences of the loading on the weight bearing soft tissues accompanied by pressure concentrations appears to be the occlusion of the veins, which result in deficiency in nutrition and oxygen needed for the tissues and the removal of the by-products. Fatigue and pain follow a hampered circulation of metabolites, experienced in the buttocks the lower limbs, accompanied by a sensation of numbness. Another implication can be compression of nerves, especially the sciatic nerve, which is protected by the gluteus muscles, leads to numbness and pain through to the lower limbs. The mass and the size of the muscle have been indicated as important factors in the ability of resisting these mechanisms.

Hadley and Haslegrave (2000), stated that epidemiological studies indicated a high prevalence of low back pain and discomfort in drivers through the years, especially in professional drivers who spend a considerable amount in the car. In all discomforting mechanisms, the "exposure" period has been stated to be the vital parameter (Troup; qtd in Reynolds,1993).

The understanding of these relationships between the seated posture and factors related to "human functioning" are vital for establishing the objectives of a seat design (Hubbard et al.,1993). The fact that, circulation forms the basis of health via correct functioning of organs limbs and the human body as a whole entity points out that, no single, fixed, "optimum" postural geometry can prevent discomfort for prolonged sitting postures (Reynolds,1993; Gross,1994; Pywell,1993). Researchers advocate that sitting should be dynamic, and postural change is obliged for physiological reasons (Reynolds,1993;Gross,1994).

Ergonomic intervention on seat design has tried to assist the necessities of supporting the human body in part while trying to avoid impediment on the physiological requirements. However the ergonomic savvy of the amount and the appropriate assistance and other necessities complicate the balanced implementation of the guidelines derived from studies.

3.2. Ergonomic analysis, guidelines and considerations for automobile seat design

Today, although a decade after Reynold's (1993) the categorisation of automobile driver's seats still follow two major typology's. Performance seats (bucket seats, mono carbon fibre frame, rally or racing cars), which are characteristically firmer, harder and touring seats, split seats (stamped frame of certain metals, passenger car) which offer more in terms of flexibility, relaxation and less constraint to movement. Between these two major poles, seat design and its features may take its shape according to the intended vehicle concept, leading to designs such as harder and more prominent side bolsters, and firmer passenger seats etc.

Basically the automotive seat like any other seat has a primary function of supporting the needs of the body in the context of the demands of the environment and the task in hand, which is in this case the automobile (Reynolds,1993). Unlike home or office seating, the automotive seat has to satisfy ergonomics considerations in both the static and dynamic environment, while also performing in extreme conditions as well (e.g. crash situations, temperature extremes) (Pywell,1993). The extent to which these affects of the constraints, the environment and the activity on a proposed variety of individuals are understood and formulated, the extent of the design of the seat and its characteristics (functional, dimensional, aesthetics…etc.) are guided (Judic et al. ,1993).

In terms of driver's seat design, Reynolds (1993) has pointed out wisely that the "ergonomic" design should basically satisfy four design criteria.

- the seat should *position the driver* with unobstructed vision and within reach of all vehicle controls
- the seat must *accommodate* the drivers size and shape
- the seat should be *comfortable* for extended periods
- the seat should provide a *safe zone* for the driver in crash.(99-100)

Today safety considerations have become a major branch of its own therefore the first three items (position, accommodation and comfort requirements) are being addressed by studies of "ergonomics of automobile seat design".

3.2.1. Seat attributes for positioning of the body

Society of Automobile Engineers (SAE, 1994) occupant accommodation design tools and models address the positional requirements for the "optimal interaction" of the driver with the automobile interior geometry. As advocated by Reynold's (1993) the

need for the vehicle and the seats to be designed for optimum occupant postures rather than positions of adaptable

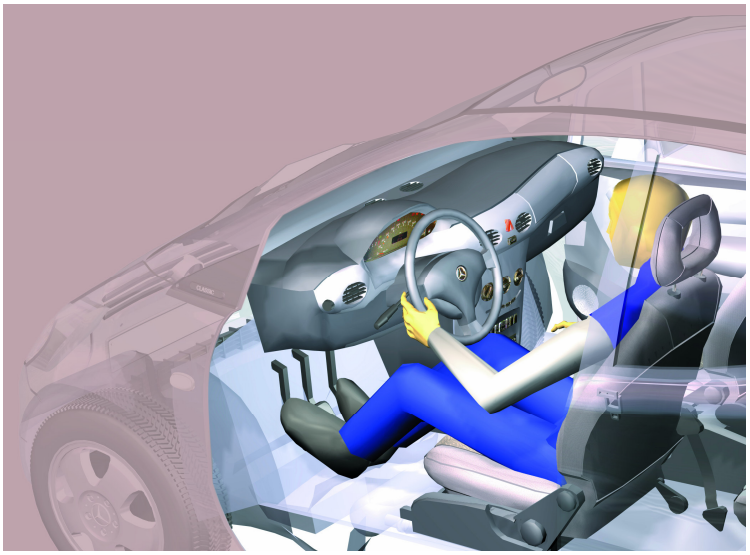

Figure 3.2 A typical posture adopted in the driving environment of a car (RAMSIS)

Ref. Ramsis in der Mercedes A-Klasse
http://www.humansolutions.com/automotive_industry/picture_db_en.php (03.09.2006)

operators have been in part addressed by the studies in the ASPECT program, which provides "whole body" driving postures adopted by individuals, rather than only supplying statistical summarised information about certain body landmarks. The position of the seat adjusted by drivers in relation to the task geometry depends on several interacting variables possessed by and imposed on the driver.

However in positioning each occupant in an "optimal" position relative to the vehicle package, according to Reynolds (1993), the seat has to basically provide three adjustments; vertical, horizontal, and the seat back angle. Basically the horizontal adjustment is intended for the leg length difference when seated, the vertical

addressing the sitting eye height differences of drivers and the back angle for the differences in arm length and hip angle (Reynolds,1993). The allowable range of positions by these adjustments should be adequate to satisfy the vision and reach capabilities of the driver. The ranges of adjustments are driven from manikin models as previously described, which basically utilise the basically comfort angles or more detailed biomechanical (the spine, pelvis, thorax) approaches.

However models may prevail inadequate due to occupant preferences where justification of models via experimental data is obliged.

Horizontal adjustment ranges have been supplied in the literature, which recommends a minimum 150mm length (Grandjean,1980; Rebiffe,1969: qtd in Reynolds,1993), but as stated by Reed et al. (2000) in many vehicles the seat track length have been found inadequate to allow occupants to select and accommodate every driver in their preferred location. Reed et al.(1999) in concordance with the SAM (seating accommodation model) has stated that 196mm of total track travel was needed (the results were based on U.S. anthropometry). Another point in the matter is that preferred locations of drivers are affected by the seat track angle, which influences the vertical positioning of the occupant (Judic et al.,1993).

Vertical adjustments accommodate differences in sitting eye height of the drivers. The design H-point travel is major determinant of this adjustment. However as the automobile seat is a deformable surface, this range of adjustment in seat height has to be determined empirically owing to the differences in seat cushion stiffness, back angle, and occupant body size. (Reynolds, 1993)

Seat back angle adjustments account for the differences in arm length and occupant preferred hip angle (Reynolds,1993) . According to Reynolds the seat back recline angle varies in between 15-25 degrees from vertical in general. American drivers

preferred back angle has been stated as 22 degrees (Nakaya& Okiyama,1993). However every seat has a "design seat back angle" established by the manufacturers, which can vary between 21 to 27 degrees (Hubbard and Elton,1993). The adjustment range of back angle should not be less than 10 degrees (Referbie 1969;qtd in Reynolds,1993). However today most automobile seats possess ranges which enable reclining almost 90 degrees from vertical. In scope of the increments of the adjustment features, Judic et al.(1993) stated that "…increments less than 5mm in the x or z direction and less than 1 degree for seat cushion or back angle." have been found unjustifiable and unprofitable, however the information is a decade old.

These adjustments can be accounted for the need, in accommodating the anthropometrical diversities of drivers in relation to the vehicle geometry, not to be confused with the accommodation geometrically offered by the seat entity itself. However it should be acknowledged that factors can not be isolated totally due to the interaction of the driver with the whole setting at once.

Reynolds(1993) states that other adjustments beyond these customise occupant comfort, which today can be increasingly found in the common automobile seat. Each degree of freedom or direction of adjustment is referred to as "one-way", and in today's most basic automobile seats three-way adjustments are a given. Up to ten-way adjustment has been supplied in the recent years.

However recent studies on the issues in particular the seat cushion angle and the lumbar support adjustments has been stated to affect the drivers sitting height and sitting eye height range, which in cases accommodation models become deficient and the ranges accompanying it.

Another important fact is that the current models of positioning manikins and deduction of seat position ranges relied on "least postural discomfort" or comfort

angle based approach (till SAM), determined from postural studies conducted both in production vehicles and seating buck configurations. Therefore increased adjustability and adjustment features can affect these comfort angles imposing postural changes causing discomfort used in conjunction with manikin models.

However constrained by vision and reach, human operator have been reported to select the same seat position in repeated trials (Verriest and Alonzo,1986; qtd in Reynolds,1993).

3.2.2. Driving Posture of the body and Postural Comfort

The driving posture is considered to be the "spatial organisation of the body segments" in the activity (Judic et al., 1993; Buti, 2001). On top of the position of the body dictated by geometric dimensions of the occupant and the workspace, the driving posture is governed by the biomechanical, psychological and physiological states of the occupant, exposed to other external factors such as vibration duration and etc. (Reed, 1998). Considering the seat being an attribute of the workspace, in terms of postural support, the seat design has to ensure the reduction of postural stress, optimising the muscular effort needed by adequately supporting the body while avoiding unnecessary constraints in freedom of movement needed for precise manipulation of controls (Akerblom,1948: qtd. in Reynolds,1993; Judic et al., 1993).

If supplied, these criteria enable the expenditure of the least amount of energy while assisting the needed awareness in relation to the task plus providing ease and efficiency of control manipulation (Pywell, 1993).

In order to address the diverse population of drivers having varying preferences of driving postures, postural studies investigate and supply the range of postures, adjustment ranges and related criteria that are needed to be addressed at "optimum"

by the seat design (in context of the seating package). In this scope joint angles are the most deterministic information which relates posture, anthropometry and seat adjustment ranges (Reynolds, 1993).

Rebiffe (1969) (qtd in Park et al.(2000); Porter et al, 2001) has analysed the driver's task and used a biomechanical model of the body to theoretically compute its posture and position based on driving task and visual demands. Grandjean (1980) (qtd in Reynolds, 1993; Porter et al, 2001) has also conducted experimental studies regarding ranges of angles. Reed et al. (1991) (qtd. in Park et al.,2000) and Porter & Gyi (1998)(qtd. in Porter et al., 2001) the need for details of the actual postures adopted by individuals was revealed, due to the incoherency of particular published joint angles which were based on theoretical calculations and real world ones. Porter and Gyi (1998) (qtd. in Porter et al.,2001) conducted experimental analysis with a fully re-adjustable driving rig, to find "observed" optimum driving postures and positions of the main driving controls.

Comparisons of the available literature on the subject of "least discomfort angle" ranges are given in table 3.1.

Table 3.1 Table of postural angles of comfort

Note: Reprinted from Porter, J.M. Porter, C.S. Chapter 9: Occupant Accomodation:An Ergonomics Approach 233-275: In An Introduction to Modern Vehicle Design Julian Happian-Smith Ed. 2001 Buttrworth-Heinemann Ltd.

	Rebiffe (1969)	Grandjean (1980)	Observed (Porter,1998)	95% confidence
Neck inclination	20-30	20 -25	30-66	29-63
Trunk-thigh angle	95-120	100-120	90-115	89-112
Knee angle	95-135	110-130	99-138	103-136
Arm flexion	10-45	20-40	19-75	16-74
Elbow angle	80-120	-	86-164	80-161
Foot-calf angle	90-110	90-110	80-113	81-105
Wrist angle	170-190	-	-	-

The important limitation of the information supplied is that they supply 2-D joint angle information rather than 3-D joint angles (Park et al., 2000), therefore the practicality of the information leads to omitting of other details. Another important point to ponder is that, in case of the usage of the joint angle ranges without the consideration that some joints in reality are connected by various muscles and tendons, will lead to inappropriate appliance of the information. Also there is always a possibility that a posture within the acceptable limits of the proposed ranges may lead to discomfort in another way (Judic et al., 1993). Therefore as stated earlier postures proposed by biomechanical models or human linkage models do not assure the preferences of the drivers.

The correlation of certain joint angles form the basis of the description of the behaviour in relation to the body size of individuals, in relation to the seating package and adjustment ranges of the seats. In all major studies it has been stated that, smaller subjects do tend to sit closer to the steering wheel however this does not necessarily mean that they possess smaller angles (e.g. knee, elbow) compared to taller subjects. Smaller subjects prefer higher seat heights in order to manipulate the steering wheel easier and to establish the necessary visual field demanded by the task. Taller subjects have been reported to prefer driving with their arms stretched. As the stature of the subjects increase the preferred a seat position moved farther back (Park et al.2000).

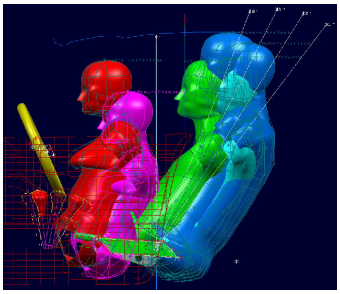

Figure 3.3 Female and male postures adopted in driving with respect to population percentile manikins

Ref. Ramsis-Torso http://www.human-solutions.com/automotive_industry/picture_db_en.php

In terms of gender, females have been found to prefer to sit closer to the steering wheel, which has been attributed to the strength required for biomechanical manipulation and anthropometric characteristics. Also noted, joint angle ranges measured and preferred driving postures can vary between nationalities and different races (e.g. Koreans and Caucasians) (Park et al.,2000).

However, in production cars unlike controlled laboratory studies preferences are limited by the seating package. Porter and Gyi (1998) (qtd. in Porter et al,2001; 254) stated that that a "driving work station" accounting for the mid-range of preferable ranges of joint angles will not guarantee that occupants would be able to sit in their preferred driving posture and concluded that at present no production car compared fits all users comfortably. Another important finding was that to obtain optimum postures in the driving work station, it was found necessary that the steering wheel position has to be adjustable, extensively both in horizontal and vertical directions (Porter and Gyi; qtd. in Porter et al, 2001:254).

Reed et al (2000) concluded that if the vehicle and seat geometry was varied under controlled combinations, occupants adapted by primarily through changes in limb

posture, where as torso posture remained fairly constant. Reed et al. (2000) pointed out that seat height, steering wheel position and seat cushion angle had significant and independent effects on posture where these were independent of body size, proportion and gender. The effects of seat height, steering wheel position and seat cushion angle were reported not significantly different for the two types of seats tested and considered the affects on posture independent of the seat type (one of the seats was firm and has a prominent lumbar support and the other was minimal contoured and bolstered).

In scope of the studies in literature it can be deduced that, postural studies emphasises the adjustment functions and ranges of the seat where geometrical interactions with the whole seating package are of prime importance. Therefore the **"postural comfort"** studies in general emphasises the seats adjustment characteristics independent of physical attributes and isolates them in certain parametric shapes such as the seat pan, seat back and the adjustability ranges of these attributes such as the seat cushion angle seat back angle etc. Therefore accommodation necessities and the preferences regarding the various seat's geometric features are addressed by other ergonomic guidelines.

3.2.3. The seating geometry for anthropometric accommodation

Ergonomics criteria related to anthropometry have been the aspect of accommodation and comfort, which has been cited in many seating considerations (Akerblom, qtd. in Kolich, 2000). Today it is common that the demand on designers that a range of people, from smallest to the largest has to fit in the seat. As a consequence of the diversity of target population intended to be sold, generally varying from 5^{th} to 95^{th} percentile, the automobile seat's geometrical features have

been aimed for accommodating 90 percent of the population. This imposes physical dimensions and limitations generally on the one single seat design, which has to account for the differing morphologies, sizes of the drivers both in the static and dynamic nature of the human body.

The static geometry of the human body for the determination of seat dimensions can be derived from static (conventional) anthropometric measurements. However published anthropometric measurements do not include a margin for clothing and generally automobile seat are used in cold climates with heavy clothing or in all sort of occasions where even high heels are worn. The dynamic geometry of the human body however has to account for the "functional positions" of the human body and its parts (Reynolds, 1993). These positions of the body are derived from mechanical models of the human body, which account for the representation of the human spine and limb postures adopted by individuals.

If a parametric approach is adopted, the seat cushion (pan) size accommodates the driver's buttock and thigh dimensions. The cushion breadth is designed in accordance with the 95^{th} percentile female sitting hip breadth as a specification limit, as this body size is greater than the male's. Any prominent lateral supports or contours must accommodate this physical size such as in the bucket seats. Reynolds (1993), based on the recommendation of Grandjean's studies (1980), has stated that this value has been set as 480mm accounting for the leg splay and clothing. According to Kolich (2003), Reed et al (1994) stated a dimension of 500mm at the hips. However according to the study conducted by Kolich (2003),occupant preferences of this dimension varied between 446-483mm.

The cushion length affectively plays a role in thigh support and accommodates the driver's buttock and thigh dimensions. The most important consequence of a cushion

of inappropriate length is that if it is too long, it will lead to a cut off the necessary amount of circulation of blood (via pressure applied), between the lower leg and thigh in smaller people due to limb length. On the other hand if the support is too short, it will be unable to provide adequate support for taller people having longer limbs which will mean strenuous activity in keeping the adequate posture. In either case a discomfort will prevail locally (Reed et al.,1994:qtd in Kolich,2003). The cushion length, from the seat back to the "waterfall" line, is specified by the buttock-to-popliteal length of the 5th percentile female dimension of the population. These values have been provided by Reynolds (1993), depending on Grandjean(1980) as 440mm, where he advocates that if an adjustable thigh support is provided it should not increase more than 105mm. Kolich (2003) has pointed out that 440mm equates to 305mm from the H-point, which is the limiting dimension. However in his study he also concluded that occupant preference for this value was 362mm or higher.

In terms of seat back design, as stated by Reynolds(1993) in considerations of the height of the seat back, the dimensions have to be deduced considering that it also acts as a vision and arm reach barrier for the driver. In design specification, the seat back eight is specified by the 5^{th} percentile female sitting height shoulder value. This value has been recommended as 509mm.

The seat back with three major areas can be identified immediately the lower hip, lumbar region and the upper (thoracic) part of the support. The side bolsters act as lateral supports. According to Reynolds (2003), the lowest values for lateral space requirements are determined by the largest torso values at the hip, waist and chest dimensions of the population. Therefore the 95^{th} percentile hip dimension determines the breadth of the hip location, where the 95^{th} percentile male determines the waist and the chest breadth to be accommodated. The common seat therefore tapers from

the hip location to the chest from a dimension of 440mm to 367mm at the chest. Pointed out by Kolich (2003), in the upper seatback (at approximately chest height), the minimum width should support the chest breadth of a large male when reclining Reed et al. (1994, qtd. in Kolich,2003) has stated that the lowest of seat should be able to satisfy 471mm ,the intersyce distance of the 95th percentile male. Kolich (2003) has displayed that occupants preferred a value of at least 514mm.

However this value can be constricting in shoulder movement. The shoulder region of the seat back has to consider both the static and the dynamic breadth of the divers. Granjean (qtd in Reynolds,1993: 108) has recommended 480 mm for the back breadth at the shoulder height where this has been conducted in scope of accommodation requirements. Kolich (2003) based his analysis for showroom comfort (short duration), in static conditions with no tasks assigned for the subject to carry out, which reflect preferences.

Another important but less referred to subject is the side support bolsters. Although there is not much literature available on the subject providing design dimensions, the seat back has to offer some sort of lateral support against lateral accelerations created during cornering and also the seat pan. This fact may be due to the fact that these features of the seat design generally are required for performance cars and studies on seat comfort generally dwell on mid range segment cars, which do not offer this amount of performance. One of the seldom studies carried out on the subject of side supports by Coelho and Dahlman (1999) did not propose any dimensional characteristics related to the problem. However due to the observations, if a prominent "firm" support in the seat pan is supplied, the buttock area should not be restricted and the length of the thigh should be supported. For the seat back, the

support should be able to accommodate the smallest intended driver's sitting armpit height without inferring the muscles.

In production cars, the lower part of the side bolsters tapers for the hip breadth, which again is governed by the largest hip breadth. Reynolds (1993) has referred to the subject in the context of bucket seat, which generalised the design recommendations such that the bolstering and lateral contours had to accommodate the physical dimensions of the torso. As in general they are hard to flex they can prevail non-habitable conditions for the drivers if not adequate space provided. Therefore the more prominent the elements, the seat design become partitioned due to functional considerations affecting the visual appearance.

In the scope of anthropometric accommodation criteria from automobile seats, Kolich (2003) has concluded that there were discrepancies between the published data and occupant preferences related to the height of the apex of the lumbar contour seatback width cushion length and cushion width. Kolich (2003) advocated that published ergonomics criteria related to anthropometry is not necessarily perceived as more "comfortable". This is supportive to the statement by Reynolds (1993) that where he notes that dimensions such as the lateral space supplied in seats, especially in bench or split seats are for psychological or visually "perceived comfort". Therefore although the current seat designs are designed for anthropometric accommodation as stated by Gross et al (1994), this is necessary but not a sufficient condition for comfort. Comfort can not be based on "adequate" dimensions, therefore the need for inclusion of psychological factors affectively for dimensional purposes is needed.

3.2.4. Seat Backrest and Seat Pan Contour

The contours of the backrest and the seat pan are important factors, contributing to the drivers sitting posture (Hubbard et al., 1993). A well-designed seat should fit all sizes and shapes of users where longitudinal and cross sectional contours have to accommodate the various sizes of people (Reynolds,1993). In order to eliminate any problems regarding the geometrical interaction of the human body and the seat surface, appropriate models of geometric contours have been developed in the scope of the physiological and morphological factors of seating comfort. The models mainly account for the appropriate pressure distribution avoiding any intrusive interaction while providing support for the body. However occupant interaction with contours is not a static phenomenon, where loaded and unloaded contours vary the characteristic of the interaction (Reynolds,1993). This in major determines the physical perception of seated comfort.

One of the prime targets of contouring is to avoid excessive shear forces between the occupant and back, supporting the occupant torso. According to Reynolds (1993), to enable this, the seat back pivot point should be located approximately at the D-Point where the buttocks deflect the seat cushion most and act as a pivot for the rest of the torso. At least 65 % of the weight of the body is supported by the buttock and according to the seat back angle preferred this will vary. As there has been to date no universally accepted research that definitively outlines an optimal backrest angle (Kolich et al, 2003) the occupant body mass supported by the seat back differs according to preference. Mass distribution and body internal force-moment models do provide an understanding, but does not account for the individual preferences (Hubbard et al,1993).

The inadequacies of the SAE H-point manikin as a design tool were mentioned however in terms of seat back contour development, Nakaya and Okiyama (1993) have especially stressed that due to the absence of convex vertebral portion of the SAE manikin in the longitudinal curve (in the sagittal plane), a design according to the template would create too much pressure at the back and weak lumbar support for the occupants. Hubbard et al. (1993), suggested that the back curves used for their study, had the lumbar region curved and the upper shoulder region lied farther rearward of SAE template. Thereby it was concluded that the SAE 2D template based designs would force the shoulder forward of the occupants.

Nakaya and Okiyama (1993) carried out the development of statistical back contours for 50^{th} percentile stature with 50^{th} percentile weight and for 95^{th} percentile stature with 95^{th} weight and concluded that compared to the SAE manikin the human contours were much "curvaceous" and the radii of the curves were bigger. In terms of development of seat back contours they provided relations for pelvic height, which is important for the identifying the amount of immersion of the occupant in to the seat. It was concluded that pelvis height measured form the subject's posterior iliac crest, related to both subject weight and hip width. Hubbard et al. (1993) has analysed and modelled the geometry and motions of the torso, supplying detailed information of the pelvis, lumbar, thorax/ribcage segment and the spinal column in a 3D JOHN model. Based on planar skeletal motions, a representative drafting template was constructed displaying simply the motions and articulations of occupants. The behaviour of the hip joint centre (HJC) in relation to the occupant size was analysed which was found to slide forward and the cushion deflected with the weight of the larger occupant (Hubbard et al,1993). Larger occupants have larger hip and longer pelvis which is further away from the back of the seat about 2mm. This is crucial as

the back axis of the contours have to account for the deflection At the D-point where mostly the ischial tuberosities located, therefore a spring constant characterising the seat pan deflection has to be derived associated with the stiffness of the seat (Hubbard et al.1993; Reynolds, 1993). The seat cushion has been stated to deflect typically 30-50mm from the undeflected surface according to Hubbard et al.(1993), however this may show variance according to the seat characteristics.

Hubbard et al. (1993), deduced that with the Michigan State University(MSU) 5^{th} percentile female, 50^{th} percentile male and 95^{th} percentile male positioning back curves, which showed a congruency on all seats, it was possible to design one single back contour for a large section of the population when seat deflection values are supplied.

The seat pan contouring, heavily depend on the criteria of pressure distribution as most of the weight bearing structures of the body interact with the contours of the seat pan. Various approaches have been adopted to the development, where minimal contouring can be applied in case of a highly deflecting surfaces provided or if a stiffer and firmer seat is desired a more contoured surface will be appropriate for better pressure distribution (Reynolds,1993). The "stiffness" aspects will be discussed in the proceeding section.

Seat cushion angle is another major point affecting the design as the "waterfall" line of the seat and the thigh support depends on the angle. A prominent thigh supporting cushion may be needed according to the angle proposed vice versa where these affect the lumbar flexion and overall torso recline. However too much contoured seat equipped with too prominent lateral supports will lead to a " constrained" posture and this "fixity" has been stated to be an important negative factor for comfort

(Grieco,1986, qtd in Andreoni et al, 2002), the occupant should be able to change its position when he/she wills to do so.

However most of the contour development today takes place in the cad environment according to the morphology of the CAD dummies positioned in seated position. The "master contour" development enables all types of contouring to be carried out on a predefined surface. Audi uses a parametric "master contour" concept for all types of sitting characteristics such as normal, sport and comfort. These form the basis for the design development of the seat surfaces (Siegmüller et al.,2003).

Figure 3.4 Contour and lumbar support development in the cad environment

Ref.http://www.worldcarfans.com/photos.cfm/photoid/3050901.001/pageview/photo/photo/1249/page/4/size/regular/country/jcf/honda/2006-honda-civic(21.05.2006)

3.2.4.1. Lumbar Support

The purpose of a lumbar support has been openly stated by Reed et al. (1996) (Pp. 19)" A lumbar support is a structure that is intended to contact the area of the lumbar

spine during sitting in order to promote postural stability by purposely stabilising the torso while promoting comfort".

The necessity of the lumbar support was derived and influenced by physiological studies of the spine, investigating the pressure changes in the intervertebral discs (carried out in cadavers) where it was found that higher pressures were adopted in sitting than in standing postures. When standing a person's lumbar spine usually has an inward curve, in contrast to the outward curve that is typical in the thoracic spine. An inward spine curvature is referred to as lordosis, while an outward curvature is referred to as kyphosis. During sitting the pelvis usually rotates rearward flexing the lumbar spine (Hubbard et al,1993). This flexion motion causes the lumbar spine to move from lordosis, flattening to kyphosis. Sitting slumped means kyphotic sitting where if lordosis is maintained lower pressure in the lumbar intervertebral discs is maintained, compared to flat and kyphotic posture due to the compressing the discs anteriorly (flexion of the spine). Lordotic postures have been regarded as more comfortable and "natural" resembling the standing geometry of the spine. (Reynolds, 1993; Hadley and Haslegrave, 2000)

However as the lumbar support forms a part of the seat back support contour, in the automotive seat, the correct positioning, mainly the height (from the H-point) and the amount of prominence is a major design issue.

According to Reed et al (1991)(qtd. in Kolich, 2003) a mismatch between the occupants back and the lumbar support, may produce uncomfortable pressure concentration or a lack of support in the lower levels of the lumbar spine. This may also lead to increase in muscular activity to maintain a desired position. According to Reed et al.(1994) (qtd. in Kolich 2003), stated that the apex of the lumbar contour should be positioned between 105 and150 mm from H-Point, which this range is

aimed to provide support the L3 joint level for both small females and large males in the sitting posture. Various other heights from the D-point of the loaded seat cushion such as 195-260mm by Porter and Norris (qtd. in Reynolds), and Grandjean et al. (1973) (qtd in Reynolds, 1993) 100-140mm above the deflected cushion surface. However this range may vary according to the sampled population and the various lumbar height of the population. Therefore the amount of variance of the height require and adjustable lumbar support.

Another major issue is the amount of prominence that should be provided with the radius of curvature of the surface.

Anderson et al. (1974) proposed 50mm of prominence (qtd in Kolich, 2000) and Anderson et al. in (1979) stated that 4cm lumbar curvature resembled standing posture. Reynolds (1991; qtd in reynolds 1993) proposed a radius of curvature that ranged from 206 to 348mm, 156 to 219 mm above the seat intersection point from a study addressing an investigation of sitting posture with cadavers for the United States Air Force. However these studies did not take into account the behaviour of the occupant while driving (Reed et al, 1991,qtd in Kolich,1999). Porter and Norris (qtd. in Kolich et al, 2000) when lumbar support was adjusted for individual comfort the lordosis was only half the standing which indicated less prominence needed (Hadley and Haslegrave, 2000). Automobile seat back should be designed for drivers' preferred postures rather than postures with a large degree of lordosis (Reed et al., 1996). Reed et al (1995,qtd in Reed et al. 1996) how drivers use the lumbar support did not coincide with the back and driving postures were reported more flexed relative to standing. Therefore due to the conflicting preferences with the biophysical recommendations and the inability of the occupants to perceive intradiscal pressure and micro trauma to the annulus, the lumbar support design has

to address preferences in prominence. (Hadley and Haslegrave, 2000). However the firmness of the support is another concern due to the pressure concentration, which may produce more discomfort and is time dependent.

Reed et al (1996) concluded unless that there is a poor back design, which imposes kyphotic posture, practically the seat back geometry of the seat does not affect the human back. It has been noted that even small reductions in flexion may produce large reductions in tissue stress and reduce discomfort. Supporting this statement Kolich et al. (2000), suggested that backrest with fixed lumbar supports should provide support for nearly flat spine profiles rather than for the standing spine posture. However in all cases, if possible (e.g.cost) the "four way adjustable lumbar support" will always provide the amount of desired support by individuals, due to the ability of adjustment of the height and the prominence as desired, accounting for the sitting stature, the weight and the individual preference of the occupant over a range of adjustment supplied (Kolich, 2000).

3.2.5 Seat Stiffness, Pressure Distribution and Foam Properties

Seat stiffness is an important parameter being the major determinant of the immersion rate in to the seat and the pressure distribution on the contact surfaces of the body. Like the human body the seat is composed of different materials, therefore the interaction of the seat and the human body is complex (reynolds,1993). The upholstery, foam, springs and internal framing structures contribute to seat stiffness. The firmness of the cushion has to posses a carefully considered balance, supporting the body weight appropriately while distributing the pressure according to the anatomical structures and the preferences of the occupants, and not to mention the

necessity of isolating and degrading the affects of vibration, impacts and shocks (Park et al,1998).

The variation of pressure on seat surface, interacting with the human soft and hard tissues defines a "pressure distribution". The pressure distribution is affected by seat characteristics such as contouring of the surface, upholstery seams, stitching, the foam characteristics such as the thickness, density and the suspension (Porter et al., 2001). Pressure distributions have been assumed to correlate with seat comfort because they are obtained with subjects sitting and interacting with the whole seat structure. (Ebe and Griffin, 2000). Thakurta et al. (1995) (qtd. in Ebe and Griffin,2000) performed correlation analysis between short term and long term overall seat comfort and pressure distributions at parts of the body, such as lumbar, shoulder, thigh, and ischial regions. The pressure distribution correlated with subjective comfort in the lumbar support and ischial support more significantly than shoulder and thigh support. Gross et al (1994) suggested that the preferred seat pressure distribution was as follows in Table3.2

Table 3.2 Preferred seat pressure distribution.

Region (support)	Proportion of Pressure
Lumbar	16 per cent
Shoulder	4 per cent
Back lateral	2 per cent
Ischial	54 per cent
Thigh	22 per cent
Cushion lateral	2 per cent

In a recent study conduced by (Andreoni et al.,2002) different and characteristic pressure maps were found among the subjects both for cushion and for backrest.

Andreoni et al.(2002) deduced that according to preferred postures and peaks in the pressure maps, people could be characterised by "sitting strategies" which can be derived for the seat pan and seat back separately.

For seat cushion the ischiatic and the trochanteric strategy were observed where some subjects preferred sitting more up right and the others reclined more supporting the chest more. From the profile of the average pressure along the sagittal line of backrest, three sitting strategies were identified (Andreoni et al.,2002) :

(i) the lumbar strategy, in which high pressure values were in the lumbar area

(ii) the dorsal strategy, featured by a nearly uniform pressure at the body –seat interface

(iii) the dorso-scapular strategy, where the main load was supported by the thoracic spine and the scapula

However in all preferred pressure distributions and postural characteristics, the stiffness characteristics of the seat should enable normal cellular metabolism, which depends on adequate circulation (Gross et al, 1994). Low and uniform pressure distribution interaction between driver and seat is generally desired, without local high peaks, which cause ischaemia in long term sitting (Andreoni et al., 2002). A good uniformity of pressure has been accepted as essential to avoid damage and pain to muscles and soft tissues. However uniformity by a relatively too soft cushion is not acceptable. A seat has to provide adequate support and stiffness (to the hip and lumbar regions) enabling the occupant to maintain a desired posture and change posture willingly, the seat is rendered uncomfortable (Park et al,1998).

The basic seat cushion designs for providing support relies on the "foamblock" design which normally 50mm or more thick. The physical properties of the foam such as the thickness, chemical properties of various foam layers, and the planar spring rates to determine total cushion stiffness (Pywell, 1993). Pywell(1993) states that Foamblock designs react only to static pressure distribution which is high and localised or dynamically acted up on where the springs are in tension. Studies conducted by Ebe and Griffin(2000) verify these as static seat comfort was correlated with seat stiffness regarding various square foam blocks with subjective responses. The preferences of the subjects also varied according to the hardness and the density of foam. The effect of "bottoming " and high stiffness both created discomfort.

The other major seat cushion design is the platform design which have been stated to rely on two elements (Pywell,1993). The platform less than 40mm thick has been described as a surface made up of long, oriented bonded fibers aiming to give planar stiffness. Platform designs have been stated to be relatively stiffer than faomblock designs and thin shaped ("Mercedes" automobile seats rely on this type of design). However the platform design has been stated to displace globally in a two dimensional plane of the compressive springs. Therefore unlike foamblock design which deform locally the sum of all vertically oriented springs determines total cushion system stiffness (Pywell,1993). Recently, Faurecia has developed the "Soft & Firm Seat concept", a solution in seating which is advocated to appeal to the entire population (that prefer softer seating and those that prefer firmer seating). These types of seating, like the platform design supplies two horizontal layers. The upper soft layer has been stated to be responsible for initial contact comfort and wrapping effect. The lower layer has been stated to provide firm support. (Carlton, 2001). This type of applications can also lessen the need for contouring, thereby enabling the

creation of flat surfaces. Pywell (1993) especially emphasised that the "platform pressure" is more consistent and is of office chair quality function.

Office chairs have been known to serve as the ideal benchmark for automobile seat cushion and seat back design. The Herman Miller Inc.'s Aeron office chair has been stated as the target by suppliers such as Johnson Controls Inc. The chair uses suspension fabric instead of conventional foam. However the considerations in the automotive context are highly complicated it has been stated that the conventional usage of materials and conventional methods would have to be changed drastically.

Recently another method to comfort the occupants and avoid pressure localisation, "intelligent seats" applications which adapt to the pressures at the body seat interface using sensors placed under the upholstery have been implemented. The systems decides which adjustments to make and automatically makes adjustments by inflating embedded air bladders to optimising comfort according to a model (Gross et al,1995).The seat surface adapts to the changes of the users positions and pressure peaks by reacting by re-adjusting according to the occupant**.** Gross et al(1995) reported subjects percentage rating of the "just right" sensation increased by as much as 40% in the areas of the thigh support, where thee back support and lumbar support increased considerably with respect to a baseline seat.

The "adaptive seating" is now a widely present technology in most "luxurious" segment cars (Potter, 2006). Mercedes has introduced systems which pairs of air bladders massage the back and reduce passenger fatigues and pain. Beside eliminating discomfort, another consequence of these new systems will be the less dependency on conventional materials such as polyurethane foam, which has to provide comfort for increased travelling duration (Steding,2000).

3.2.5.1. Seating and foam physical characteristics

The cushioning ability of a seat is affected by many factors that can be classified as engineering variables as follows (Park et al,1998):

- Static spring constant
- Dynamic spring constant
- Damping ratio
- Force-Deflection Curve
- The hardness of the foam padding
- The hardness of the seat cover (54)

In cushioning materials used in automotive seating, the polyurethane foam has been and still is by far the dominant material (Couretas,1997). Foam thickness and foam hardness has been considered to affect static seat comfort by researchers (Lee and Ferrioulo, 1993; Ebe and Griffin, 2001). In terms of engineering properties the force deflection curve of polyurethane foams have been discussed the most. The "indentation force deflection" (IFD), has been defined as the reaction force when indenting a foam specimen to a specific deflection (Ebe and Griffin, 2001).

The resiliency of the foam has been found to reflect the force that a car driver really feels and could be used for both short and long duration comfort feelings. Diebschlag et al. (1988) (qtd. in Ebe and Griffin,2001) recommended polyurethane foam with a linear relationship between applied force and compression ratio for upholstery suggesting that it minimises the concentration beneath the tuberosities and achieves a more suitable pressure distribution.

Gurram and Vértiz 1997 (qtd in Ebe an Griffin, 2001) reported that the stiffness obtained from cushion deflection data affected the optimisation of seat comfort. Linear spring characteristics was recommended in studies (Ebe and Griffin,2001).

The cell geometry of the foam plays an important role due to the need in deflection characteristics. Isotropic (3D, regular), or anisotropic molecular structure will affect static comfort and the "haptic sense" as well. These are related with the manufacturing techniques of the seat and foam. Alternative seat production methodologies have been stated by Lung and Hardcastle (2001) such as , pre-moulded foam cushion and squab moulding fixed with cover in place, foam in place, foam in fabric (pour in foam) and etc. Alternatives to cushioning materials have been applied such as polyester fibre cluster. In a coiled and fluffed configuration, rubber mat instead of spring and other materials have been used. However all substitutes have been stated to be not as resilient as the polyurethane foam especially in higher temperatures, where they loose thickness and support significantly.

Figure 3.5 Seat frame, springs and the polyurethane foam placed on top of the frame

3.2.6. Vibration discomfort and Ride

Through the duration of the ride, drivers and passengers of cars are subjected to vibrations and accelerations that are directly related to the characteristics of the vehicle, the road surface and the seat. The perception of "ride comfort" is also based upon road shock, impact and vibration transmitted through the automotive seat. Reynolds has stated that ride comfort has been associated with vibration since the 1940's. However the term "ride" is used for the perception of tactile and visual and the aural vibrations (Gillepsie,1992).

"Ride" is subjective perception, and is adhered to the feelings associated with the "level of comfort" experienced when travelling in a vehicle. Therefore, a combination of factors including, accelerations on top of the tactile vibrations experienced through the seat by the occupant, the hands and feet affect the ride (Gillepsie,1992). However the term "ride quality" should not be mistakenly understood from these factors as the general perception of the seat design, temperature, ventilation, interior space, hand holds and many unaccounted factors determine the ride quality.

Vibration studies investigate the vibration transmitted to the buttocks and back of the occupant along the vertebral axis via the base and back of the seat. In addition, the pedals and steering wheel transmit additional vibrations to the feet and hands of the driver, which can be replicated similar to the conditions in vehicles. These vibrations, in combination with a seated posture, produce a measurable level of discomfort for both driver and passengers, especially during journeys of long duration (Paddan and Griffin, 2002). Moreover, prolonged exposure to vibration can result in a range of physiological problems such as postural instability, cramp and numbness. Previous

investigations have also reported that both drivers and passengers of cars develop fatigue during long journeys reducing driver performance.

The judgement of ride vibration in a vehicle is still an area of controversy in the automotive community (Gillepsie,1992) . Vibrations unlike other ergonomics criteria are quantifiable, repeatable and can be measured objectively. As stated by Gillepsie, (1992) the studies focus on the tolerance of occupant to vibrations relating the characteristics of vibrations to discomfort in a seated position, in order to determine the frequency sensitivity of the human body. Tuning the seat frequency away from the vehicle's frequency and tuning the seat frequency away from the human sensitive frequencies is the general procedure in order not to create discomfort.

Exposure to whole-body vibration (WBV) causes degraded comfort, and interference with activities, impaired health and occurrence of motion sickness. However WBV is a complex phenomenon. During exposure to WBV many different psychological, psychophysical and physical factors, such as individual susceptibility, body characteristics and posture together with the frequency, direction, magnitude and duration of vibration are relevant in development of unwanted effects and discomfort. Ebe and Griffin(2000) has stated that the subjective feeling is assumed to be 'discomfort' rather than 'comfort'. Vibration in a vehicle normally contributes to passenger's "dynamic" discomfort where beyond frequency, the magnitude of the transmission is also important. It is known that vibration magnitudes and durations, which produce vibration dose values (VDV) in the region of 15 $m/s^{1.75}$ will usually cause severe discomfort (BS 6841;1987). It is reasonable to assume that increased exposure to vibration will be accompanied by increased risk of injury.

The first peak frequency where the human whole body resonance is near to 5 Hz and the second one corresponds to the upper body resonance near to 14 Hz (Demic et

al,2002). The adopted posture and the relevant body tension is known to affect these peaks, where tense bodies compared to normal relaxed postures lead to an increase in frequencies (above 5Hz).

Humans have been stated to be very sensitive to vertical "random" vibration at frequencies below 1 Hz, which can be explained by physiological factors. The human being is least sensitive at frequencies above 5 Hz. Humans are very sensitive to fore and aft random vibration at frequencies below 1 Hz, which can also be explained by physiological factors. They are least sensitive under fore and aft random vibration at frequencies above 5 Hz (Demic et al, 2002).

Another crucial element in seat comfort is the natural frequency at which the seat vibrates. If this frequency is too close to the frequency of the floor pan or vehicle structure the seat amplify the vibrations.

Conventional seats (seats with foam and metal, or rubber, springs) have been stated to have vertical resonances in the region of 4 Hz. (Paddan and Griffin,2002).Vertical vibration is amplified around this frequency and at all lower frequencies. The amplification at resonance can be a factor of two, or more. Only at frequencies greater than about 6 Hz will conventional seats attenuate vertical vibration. The amplification below this frequency and the attenuation above this frequency varies between seats.

Suspension seats, which have a separate suspension mechanism containing a spring and a damper have been reported to produce a low resonance frequency and isolate vibration at frequencies "lower" than can be isolated without the suspension mechanism (Paddan and Griffin,2002) .

The seat stiffness is also an affective parameter in transmitting vibrations to the occupant. As stiffness of the seat increases, higher frequencies are transmitted,

therefore cushion design and fabric (upholstery) stiffness are important parameters related to discomfort.

Vibration is one the most important issue in seat design as it is the most important contributor to health related criterion, reliability and quality (Hall,2001). However the higher frequency vibrations, "sounds" which may be considered as "noise" possesses as much importance as smaller frequency vibrations, to vehicle users.

3.2.7 Acoustic Comfort and Noise

Noise has been defined as any acoustic phenomenon that annoys the individual hearing it (Kroemer et al., 1991). Any unwanted objectionable or unacceptable sound annoying a subject is conceived as noise. The tolerance threshold varies form person to person depending on the sensitivity, mental state of the individuals and conditions present. Therefore noise is highly psychological sensation and subjective. However certain conceiving of noises can be attributed to a whole population, as unwanted, disturbing and concerning.

A noise coming from an automobile seat can be disturbing where it may even create distrust in certain circumstances, so it is an important phenomenon for "perceived comfort" due to the adherence of the values to the "overall seat comfort". Seat suppliers such as Lear, Johnson Controls, Magna and Faurecia have been reported to carry out extensive buzz, squeak and rattle testing in audio laboratories, on four-post road simulators and out on the actual road on seat prototypes and production seats (Braunstein, 1997). However the literature on the subject matters is limited.

Possible noise (sound) sources are materials rubbing on each other or joint locations of structures such as springs, adjusters, integrated seat fans and etc. Therefore it can

be stated that the basic objective is to eliminate all sounds that can be perceived by the customer as "noise".

3.2.8 Thermal comfort

The thermal comfort definition has been provided by American Society of heating, refrigerating and air -conditioning Engineers (ASHRAE) standard 55-56 as follows (Kroemer et al., 1991):

" That condition of mind which expresses satisfaction with the thermal environment, the person does not know whether he or she would prefer a warmer or a cooler environment "

The thermal balance of the occupant basically relies in the energy exchanged with the environment by certain mechanisms classified as:

- Conduction
- Convection
- Radiation
- Loss of moisture (which is only one way and possesses the cooling effect due to latent heat of evaporation)

Other minor way is the mouth respiration.

In relation to the automobile interior, the ambient temperature can be acclimatised in a range of adjustment in the most basic cars today to a certain extent(if air condition is present). However the most significant contact surface and structure supporting the occupant body is the automobile seat, where a complex thermal interaction takes place.

The seating characteristics that may contribute to the thermal perception of comfort have been stated as (Fung & Hardcastle,2001):

- seat cover fabric
- the laminate material inside the seat cover
- the squab and cushion
- the seat design as a whole
- body metabolism
- fibre type in clothing
- layers of clothing

On top these parameters adhesive films and barrier films can affect the seat thermal comfort, according to the production method of the seat.

In general, with few exceptions, suppliers have stated that consumers do not tend to comment about climatic comfort of the seat unless there is a problem (Nelson,2001).

However in order to supply comfort, the materials have to possess certain properties. The perspiration of the body is major concern area. The transfer of water vapour from the skin through clothing and the seat is important for comfortable seating. It has been stated that if moisture accumulates between the occupant and the seat surface, the occupant quickly becomes uncomfortable and discomforted due to loss of evaporation as a heat transfer mechanism and increase in skin friction (Adams et al 1982; qtd in Reynolds. 1993). Therefore the breathability of the cover material is important. Deep sew lines in the seat cover act as channels for air circulation.

The heat retention of the upholstery is another important issue due to the shock that it can give to the occupant in the initial sitting phase. The perception of hot and sticky

seats have been sated as a problematic area by suppliers, leading to discomfort (Steding, 2000). The foam thickness and the porosity of the foam is another major factor, determining the breathing ability of the seat cushion and the comfort perception (Reynolds, 1993). Also the foam acts as a good insulator of heat, therefore over heating can occur.

The time to acclimatise the occupant according to the desired level of comfort have been tried to overcome recently by the introduction of ventilating fans integrated in to the seat cushion and back. The vacuum created and drawn through the air compartment from occupant-to-seat contact surfaces, have been advocated to remove heat and moisture, and comfortably cool and dehumidify the occupant's back and thighs preventing discomfort (Stending, 2000).

Also convective heat transfer systems (thermo-electric devices) that enables direct contact with the occupant have been applied.

In this manner the time to thermally comfort the occupant have been reduced and the occupants perception of comfort have been enhanced via the seating modules, being independent of the rest often Heating Ventilation Air conditioning (HVAC) systems of the whole interior (Nelson, 2001).

The flexible system has overcome the thermal comfort criteria desired by different levels of individual preferences related to the seat. However the basic seats which are found in high volume cars have to still supply basic criteria mentioned earlier in conventional ways which may have implications on the visual aspects of an automobile seat.

Figure 3.6 The effect of ventilating fans integrated in to the seat cushion and back

Ref.http://www.johnsoncontrolspress.com/ALL_PressImages/passiveclimate_100k.jpg (03.10.2006)

3.2.9 Olfactory Sense and Odour Comfort

The olfactory sense is triggered by molecules, which are basically made up of sensors located on the olfactory epithelium in upper part of the human nostril. The concentration of the odour plays a major role in the triggering of olfactory and trigeminal sensors. However it has been stated that little is know systematically about the assessment of "odour annoyance". (Hangartner, qtd.in Kroemer et al., 1991). High enough concentrations of certain odour qualities have been stated to be capable of unfavourable responses such as nausea, vomiting and headache. Other low concentrations of less hazardous and irritant effects can lead to destruction of the sense of well being, decrease in heart rate, constriction of blood vessels of skin and muscles. In these responses the intensity and exposure have been stated to be important and irritation characteristics have been classified similarly to noise classification.

In context of the automotive interiors and particularly the seat, the ideal sensation of an odour in a car has been stated as the "new" sensation. However the most fundamental target the studies held has been to create the most "natural smelling" car

(Masson,2005).The seat components affecting this sense can be trim and upholstery textiles (wool suede,etc.), adhesives, foam and other ingredients which are capable of diffusing molecules in various conditions(e.g. temp extremes).

However in literature the most debated odour above all others has been the "Leather" upholstery as the shortage of leather has lead to alternative man made leather types. The odour of natural leather generally has been regarded as a luxury attribute, a noble material in the luxury range, a "haute couture" image contributor to the overall image (Fung and Hardcastle, 2001). However it has been stated that some Japanese customers dislike the image projected by it.

Another important point is that the mixture of odours of a number of materials can lead to various other odour which can be discomforting, where as the original odours might not posses and irritating odours. Therefore the whole car odour becomes more important, that a particular seats odour , how ever the seat as a component has to embrace a certain odour or at least none, which has the potential of discomforting the occupant.

3.2.10. The tactile, fabrics and upholstery

In ergonomic literature dealing with the upholster and the textiles of automobile seats, the functional properties of stiffness, frictional and thermal properties of the materials have been discussed the most, leading to the occupant and seat interaction (Reynolds 1993; Park and Hook, 1998)

Park and Yook. (1998), tested the "comfort" properties of covering textiles of car seats as follows:

- Air permeability
- Electrostatic propensity

- Resistance to soil
- Water repellency
- Water vapour transmission

It was stated that low electrostatic propensity (electric shock), high moisture transport (thermal comfort), high resistance to soil (clean surfaces), good cushion and comfortable warm-cool sensation were the main comfort properties demanded from seat covers (Park and Yook, 1998).

In their study evaluation for leather, woven, pile knit textiles were made. Park and Yook (1998) concluded that woven seat cover was used most widely but the luxurious and soft textured leather seat cover was preferred. This has been attributed to good seating comfort however, it was concluded that if the woven, synthetic leather and pile knit seat covers additionally have the luxury impression, the preference of the subjects seat covers could be different.

Leather has been globally regarded as the ultimate luxury in automotive seating regardless of its functional properties. Although the seat comfort is strongly influenced by fabric properties, impressions such as "luxury" have been stated to overwhelm the subjective assessment of comfort.

As stated by (Fung and Hardcastle, 2001), textiles allow the production of overall mentally relaxing interiors which depend on the fabric design and colour. However it has been stated that a quality material should not let down the expectations of the user and the touch of the material should be in accordance with the appearance of the material (Masson, 2005). The first perception when entering a car is the visual sensation, after that the touching sense will proceed. It has been stated if the hand does not confirm the sensations that we visually perceive than everything can irritate

and this may negatively affect the purchase of the car (Masson, 2005). The initial perception of the design invokes a perception however the "feeling" has to enforce the visual perception (Snook,2003).

The taction sense is the reaction to "touch" with the skin. In literature, the term "tactile" has been used if the stimulus received is solely through the skin, whereas the term "haptic" has been used if the information has been obtained simultaneously through cutaneous and kinaesthetic senses (the skin and the proprioceptors in muscles tendons and joints) (Kroemer et al.,1991).

According to Kroemer et al. (1991), the taction sense through mechano-receptors have been stated to be differentiated by the humans due to:

- Magnitude of mechanical deformation
- Temporal rate of change
- The size and location of the stimulated skin area (i.e. the number of receptors stimulated)

Generally the properties of textiles are rated through criteria such as elasicity, warm, cool, sticky, hard, velvet elastic (Masson,2005). All are perceived in different ways. Perceived feel is determined by texture, compressibility and other properties (Snook,2003). It has been stated that the "Soft-touch" has been increasingly the differentiator and performance criteria in enhancing the perceived value. However textile researchers have been trying to find out how the brain makes assumptions about the surface texture and feel based on purely visual clues. Snook (2003) has stated that researchers have discovered that some soft touch materials clearly give the impression before the surface is actually felt.

3.3 Conclusion

The seat attributes and the seat features have been summarised in table 3.3 and displayed in figure 3.9

Figure 3.7 Cross-section of an advanced seat structure and components

Ref. Reprinted from Demmer et al. " Geborgenheit durch Harmonie von Technik und Ambiente" ATZ , Mercedes Benz E-Klasse, Supplement, Mai, (2002):70

The literature on ergonomic seat design characteristics provide much information related with medical, physiological, health-hazard, biomechanical, anthropometrical properties of seating. These basically form an "accommodation" criterion for a range of occupants which, aids the driver to carry out the functions of the task uninterrupted over a period of time. As stated by Helander (2003), unless the design of a seat creates discomfort via violation of basic criteria, user may not be able to rank or prefer one seat over another.

Table 3.3 Classification of Seat attributes and seat design features

Seat attributes	**Seat features**
Seat back size	Seat dimensions (functional)
Seat cushion size	Seat dimensions (functional)
Seat back firmness(stiffness)	Seat cushioning materials (functional)
Seat cushion firmness(stiffness)	Seat cushioning materials (functional)
Lumbar support	Seat back contour (functional)
Throacic support	Seat back contour (functional)
Buttock support	Seat pan contour (functional)
Thigh support	Seat pan contour (functional)
Seat back lateral support	Seat back contour (functional)
Seat cushion lateral support	Seat pan contour (functional)
Seat colour, textile, pattern	Aesthetics (functional,feel, appearance)
Physical shape of the seat	Aesthetics (overall appearance)

Designers have to consider tactile and other human perceptions as well as factors of discomfort such as pressure distribution, position of controls, postural and thermal elements, vibration and dynamic support and etc. The latter ergonomics guidelines for seat design and attributes providing the **"working"** physiology, homeostasis and geometry of humans with necessities to continue functioning avoiding discomfort are abundant and relatively established. Addressing the "automotive ergonomics" seating comfort/discomfort criteria in relation to physiological, anatomical, biomechanical criteria does not necessarily mean that comfort is established. Preferences of individuals highly affect the understanding of comfort, therefore human sensory qualities such as perception of visual appearances and visual clues have to be accounted for in a comfort understating. The definition of comfort and assessment methodology addressing the emotional and cognition based values have to be addressed in order to enhance the perception of comfort (Vink, 2002).

CHAPTER 4

VISUAL PERCEPTION OF SEAT COMFORT: PSYCHOLOGICAL ASPECTS

In terms of the visual interaction with a seat or the interior of the automobile in the pre-seated time domain, perceptual psychology and other psychological factors will be dominant. Psychological aspects refer to peoples cognitive and emotional reactions to the experience with a product (Jordan 2000). The three domains nature, culture and mind interacting in the human, determine the affect and the behaviour of the individual towards anything and any product (Koffka, 1935). Perception can be regarded as interaction with nature; communication as interaction with other humans and reflection can be regarded as interaction with in ourselves, our inner states, experiences, history etc (Brant, 1995).

Based on the Shannon and Weavers model of communication (figure 4.1), Crilly et al. (2004) depicted the visual interaction of the consumer (the unified construct of receiver and destination) with products as depicted in Figure 4.2.

Figure 1 Basic model of communication (adapted from Shannon[26])

Figure 4.1. Communication model of Shannon and Weavers

Note. Reprinted from Crilly Nathan, Moultrie James and Clarkson P. John, " Seeing things: consumer response to the visual domain in product design " Design Studies Vol25 No. 6 November 2004: 547-577.

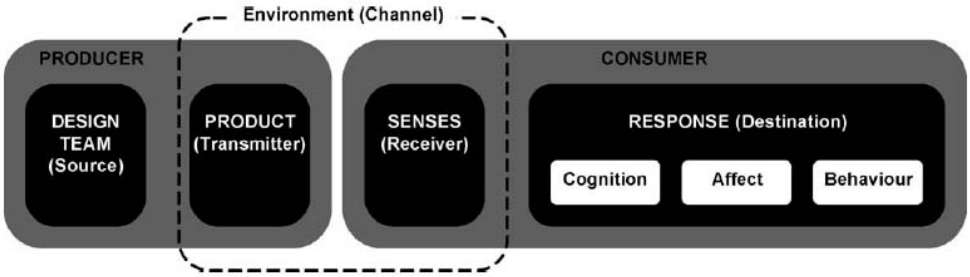

Figure 2 Basic framework for design as a process of communication

Figure 4.2 Adaptation of the design process to communication model of Shannon and Weavers

Note. Reprinted from Crilly, Nathan, James Moultrie and P. John Clarkson, " Seeing things: consumer response to the visual domain in product design " Design Studies Vol25 No. 6 November 2004: 547-577.

Crilly et al. (2004) approximated the consumer's response to being composed of cognition, affect and behaviour, where the communication medium being the products appearance, and the consumer's a perceptual sense(s) acting as the receiver of the design message. In analysing the visual comfort perception of an automobile seat, the framework of Crilly et al. (2004) forms a good basis for discussion and a road map.

4.1 The Senses and Visual Perception

Crilly et al. (2004) have stated that the complexities of perceptual psychology will not be covered and it was sufficient to state that visual perception of objects may not be an accurate reflection of their physical state. However, in the determination of visual attributes, certain topics should be covered. Actually as depicted by Griffin (2001) the user will gain information from all visual, tactile, aural, olfactory, and kinaesthetic senses about a product.

Table 4.1 Senses and their function during information acquisition about a product

Visual	**Auditory**	**Tactile**	**Kinaesthetic**
Shape	Volume	Temperature	Motion
Configuration	(Loudness)	Pressure	Direction
Size	Pitch	Texture	
Position	(Frequency)	Hardness/Softness	
Color	Interval		
(Hue/Luminance			
/Saturation)			

With respect to their development touching has been indicated as the primary of all our senses. As such vision has been sated to depend on it, starting at 4-7 months old, grabbing by infants have been linked to be used probably to integrate touch with vision. Without this integration image would be meaningless as such it would be no more than patterns (The Human Senses,2003). So it is obvious that correlation between touch and other sensorial information and vision is a primary human function in order to make sense of outside. From this point the visual perception has been defined by Corsini (2002,p. 705) in dictionary of psychology as:

> "1. In vision the ability to see in three dimensions objects in distance and also to be aware of the amount of distance from the self. 2. The awareness of (having) the senses being stimulated by external objects qualities or relations. Immediate experiences as opposed to memory; ability to select and interpret various sensory experiences in to recognizable patterns. The interpretation placed upon a stimulus or experience determined by general organization principles"

According to Levine (2000, p.184) Fundamentals of sensation and perception, perception has been defined as:

> "Perception is the development of an internal representation of the outside world based on the information presented by the senses. The representation is a functional

> description of the environment. It enables you to categorize the objects and images you see: the categories in to which stimuli are placed by subjects are often the only data available to measure a subject's perceptions".

According to these definitions a certain *awareness* and *interpretation* have been emphasised. Interpretation has been defined in the dictionary of psychology as 1. in general elucidation of the meaning of a play, musical composition, work of art or other material not easily understood. 2. in psychoanalysis it is the attempt to explain the inner significance of the patients attitude impulses dreams memories and characteristic behaviour. Therefore from these definitions we can state that visual perception has a two fold constitution. The first is being able to sensorially distinguish the given stimuli and form objects based which regards the physical rules of the outside world the formation of functional categorisation where considerable awareness knowledge is needed, whereas the second is ability of interpreting these stimuli to a meaning. The mental awareness depicted here refers to percept in literature.

Percept has been defined as a mental impression of something perceived by the senses, viewed as the basic component in the formation of concepts; a sense datum (Firth,1949). Sense datum has been defined as a basic un-analyzable sensation, such as a colour or smell, experienced upon stimulation of a sense organ or receptor. Besides sense-data the immediate mental objects of perception have been called *impressions* (e.g., by Hume), *ideas* (Berkeley), *sensibilia* (J. L. Austin), *qualia* (C. I. Lewis) and other names. According to (Levine,2000) the information from which a *percept* is formed, comprises features reported by lower order processors in the sensory system. These features facilitate in summarizing the scene without requiring a point by point description. Actually it has been stated that the design of the eyeball

due to the blind spot at the back of the eye has to dart around 3 times per second in order to form a fuzzy picture of the world around us. The brain takes the jerky snapshots and constructs a plane of vision. Because of the evolutionary design eyes have been stated to play little role on constructing the picture because of the structure of the eye. (The Human Senses, 2003). Therefore the subconscious eye movements gives information about how the brain functions on top of that it points out the importance of local processing. Actually as Köhler (1947) has depicted perceptual organisation does not occur in the dimension of space only but also in that of time. The proof can be sought in local possessing where the brain uses perceptual hypothesis to local regions to create a whole. Impossible figures have been stated to be a practical example in explaining local processing (Levine, 2000.p. 218)

In sensory experience organisation depends upon the characteristics of facts in their relation to one and other (Köhler, 1947).The inconsistency through out the whole disrupts some larger process which integrates the local properties in to a unified percept. The organization in to whole figures has been researched by the gestalt psychologists. The most prominent observation was that, when features were organized in to a figure, the figure existed as an entity that was greater than the sum of its individual features (Levine, 2000). As denoted by Koffka (1935), the look of things do not alone depend upon the proximal stimulation, but also upon the sets of other conditions which must lie within the organism .Therefore as Norman (2004) puts it, there are two processes active in perception. **Bottom up processes** are those driven by perception whereas **top-down processes** are the driven by thought. As a result we must have a *mental awareness* of a particular type of sense-data belonging to an object, not in our eyes, of (eyes are in the physical world), in the mind. The sense-data conjured by the stimuli of the visual of the object which represents the

object to us. Levine (2000) argues if there is cognitive learning, perception is to some extent a function of what is learned. Constancies such as shape, size and colour have been defined as the necessary learnt "illusions" acting on the proximal stimulus, creating a logical and stable internal representation of the world from the distorting and changing representations delivered to the sensory receptors (Levine,2000). Another very important mechanism Levine (2000) has pointed out two schemes of stimuli matching (visual). The template matching approach where comparing a stimulus to a set of possible alternative patterns and reply when the stimulus matches one of the patterns (p. 186). The main alternative to this has been described as the `feature-extracting` model. Levine (2000) has stated that the cortical cells act specifically to certain features of the visual scene such as lines angles and slopes where the visual system constructs a first sketch. Especially features such as edges curves and lines have been stated as the parts of the visual scene that will convey most information about the scene. In return the formed primitives (of a sketch) of this scene would follow in to the percept construction.

The process of grouping features in to figures have been defined as pre attentive processing (Levine 2000, p.19). In gestalt view the whole figure is imbued with a property as a unit that is not evident when it is analyzed as a collection of features (p. 185). Certain rules based upon dynamic organisation have produced laws of proximity, similarity, closed forms, common movement, good contour factor of good curve, pragnanz figure to ground relations and experience(Koffka; Köhler, 1935). These processes yield in to grouping of features where "Good form" will prevail a better perception.

Making and testing of perceptual hypothesis which is an unconscious process has been also emphasised in visual perception (Levine 2000, p. 259). People perceive the

scene in relation to the available sets of hypothesis. In these perceptual factors sets two have been underlined. The first factor set among people has been associated with the cultural background of the people where a difference in perception among people of differing perceptual backgrounds will occur. The second factor set has been stated to be dependent on more immediate experience of the perceiver. Ambiguous figures have been shown as a demonstrable example where the patterns can be perceived in either of two ways, switching back and forth between interpretations.

As a result we can conclude that, perception is itself an encoding process (Fiske,1990). Perception of the reality involves identifying significant differences, therefore identifying units, the relationship between units, which as a result make a whole. Another very important point is that our perception and understanding of reality is as specific to our culture and our language (Fiske,1990).Perception actually is creating paradigms and syntagms. As with perception memory and recall depends on the organisation of the perception and the resemblance of the previous exposures (Köhler, 1947).

4.2 The Act of Mind; Knowledge and Experience

If we are seeing (perceiving) with our brains not just looking with our eyes, the importance of how the mind works becomes apparent. In recent years the **"**Connectionist approach" which suggests that much thought results from a kind of pattern matching system one that forces its solutions to be analogous to past experiences, and one that does not necessarily follow formal rules of logical inference (Norman,1988). The approach suggests that the brain is made up of neural nets. Experiences form new bonds with other neurons learning synapses and the more the path is used the new connection is made stronger. However, due to the

workings of the brain, humans have been stated as conscious (aware) of the end states only, not of the means of getting there. As Norman (1988, p.125) explained these subconscious thoughts deals with the matching of patterns, finding the best possible match of ones past experience to the current ones. Subconscious is automatic and without effort where it is good at detecting general trends and good in recognising the relation ship between now and what had happened at the "past",. (Norman, 1988). As it is biased toward regularity and structure it has been denoted as limited in formal power not being capable of careful reasoning. However subconscious memory has been denoted as the bank of conscious thinking where conscious is slow and pondering. Conscious thought acts on thinking through alternatives compare different choices, reasoning; relying on short term memory. Therefore much of our knowledge has been stated as hidden beneath the surface of our minds according to Norman (1998), which is inaccessible to conscious inspection. Subconscious memory has an active role in intuition and remembering. Blackler et al. *(*2003) argued that the reasoning process is not in evidence when intuition is used as the cognitive processing takes place outside the conscious mind so that the steps in processing are not known. Therefore intuition relies on experiential knowledge which is active constantly scanning the environment comparing our past to the moment. Blackler et al. *(*2003) have stated as follows.

> Extremely experienced people will process at the skill-based level. This is non-conscious, automatic processing. Those familiar with tasks but lacking extensive experience process at the rule-based level. The cues in the environment trigger rules accumulated from past experience, and previous successful solutions or decisions22–24. When the situation is novel, people will operate at the knowledge-based level, which is analytical processing using conceptual information. In a real world context, a person might operate at the knowledge, rule or skill-based level and will switch between them depending on task familiarity (494).

Professionals use developed intuition in relation to their work. Users also will and can develop intuition. It has been suggested that it is possible for a novel stimulus, i.e. one not previously experienced in a specific context, to be highly associated with a group of recognised stimuli (Blackler et. Al., 2003, p. 494)). Rather than being identical with a previously experienced stimulus, just a similar enough stimuli would allow the association to a mental concept. Intuitive use or preference of a product can be accentuated by including familiar features in it, consistent with the user's expectations according to her/his past experience.

4.2.1 The Role of Knowledge and Memory

If intuition is a type of cognitive processing that is often unconscious and utilises stored experiential knowledge, types of knowledge should be defined used by the processes in the mind. Norman (1988) has made a division between the types of knowledge. Declarative knowledge (knowledge of "what") which includes knowledge of facts and rules. Declarative knowledge is easy to write down and to teach. Knowledge of "how" what psychologists call procedural knowledge. Knowledge that enables a person to perform music (Norman,1998). Procedural knowledge is difficult or impossible to write down and difficult to teach. It is best thought by demonstration and best learned through practice. As Köhler (1947, p. 266) has stated if learning is easy the reason is that material lends itself to organization Meaningful structure organize apparent chaos and arbitrariness so the context of learning or exposure is important. Procedural knowledge is subconscious. If knowledge is accomplished through **learning** it depends on the structure. As Norman(1988) has put it, when things make sense they correspond to knowledge that we already have, so the new material can be understood and integrated with

previously acquired material. Memory is what stores knowledge. Norman(1988) has identified three types of memory:

> **Memory for arbitrary things:** the items to be retained seem arbitrary with no meaning and no particular relationship to one other or to things already known.
> **Memory for meaningful relationships:** the items to be retained from meaningful relationships with themselves or with other things already known.
> **Memory through explanation:** the material does not have to be remembered but can be derived from some explanatory mechanism. (67)

4.3. The consumer's cultural context

Crilly et al. (2004) has stated that the culture, background and experiences of the consumer are influential determining their response to products. In fact all consumption is cultural activity. has emphasized that basic needs take different cultural forms. He proposed that "Objects are assimilated in to the subjective experience of individuals-or of the collectivity in the form of culture and production – by appropriating them into human ends" (102). Culture is the process of naturalization of certain norms and facts by the society living together. As such cultural expectations and meaning do have their foundations as much as natural facts and imaginary concepts originating from the human nature. Nature is the raw reality that surrounds us; however inaccessible in its own terms, `the natural` is the sense that a culture makes of nature: the natural is a cultural product, nature is pre cultural reality. (Slater 1997, p. 121) It is obvious that people can not be reduced to pre-cultural humans where only basic needs are of concern. We view the world and assimilate it both intellectually and practically in the light of subjective projects and desires. As Slater (1997) indicated once the satisfaction of basic needs has been materially secured the meaningful or cultural aspect of products comes to

predominate and people become more concerned with meanings of goods than their functional use to meet a basic or "real" need. In concordance with this statement ,referring to mature markets such as automobiles, consumers not only buy their necessity of product,but they buy a form of entertainment, experience, lifestyle and identity (Crilly et al. 2004).

Another very important aspect is that as children, starting with the first ever family owned car our judgements are being shaped which prior experience will influence perception. As Demirbilek and Şener (2003) has suggested the childhood of a user gains importance in to what he or she will interpret of a product. As Norman (2004) puts it , predisposed genetical potentials, values and preferences are moulded with current inclinations. Culture underlies (or right besides) in every choice, whether the choice is pragmatical or not.

4.4 Product Appearance and Response to Design

Product appearance is actually a holistic encounter with the product. As Janlert and Stolterman (1997) stated the sound of the car door and the car engine are parts of the car's appearance, as well as the smell and feel of the upholstery. Therefore overall appearance is actually a correlation (formation) process of the brain. Response to design has been described as comprising innate (relatively universal and constant), personal, cultural and situational factors (shows variability among consumers) (Crilly et al., 2004). The cognitive aspect of response has been conveniently described , as the products' aesthetic (aesthetic response and not product appearance in general), semantic and symbolic qualities. However it has been emphasised that these are all aspects of cognition driven by both the perception of tangible stimuli and pre-existing knowledge. Therefore rather than being objective qualities of the product

they act as classifications for different aspects of cognitive response to product. The physical product on the other hand has been stated to be characterized by its geometry, dimensions, textures, materials, colours, graphics and detailing where the evaluation of the products' qualities are perceived by the consumer.

4.4.1. Cognitive response

Crilly et al. (2004) has defined the cognitive response as the judgements of the user to the products appearance based on the information presented by the senses. This is an intellectual process based on knowledge and experience integrated with social and cultural heritage. In relation to the literature review they have conducted profoundly, Crilly et al. (2004) have identified three categories in describing cognitive response to product appearance as follows.

- **Aesthetic impression** may be defined as the sensation that results from the perception of attractiveness (or unattractiveness) in products. This is related to Crozier's 'response to form', Cupchik's 'sensory/aesthetic response', Lewalski's visual 'X-values' (which express 'the order of visual forms'), Baxter's 'intrinsic attractiveness' and Norman's 'visceral level' in design.
- **Semantic interpretation** may be defined as what a product is seen to say about its function, mode-of-use and qualities. This is related to Crozier's 'response to function', Cupchik's 'cognitive/behavioural response', Lewalski's visual 'Y-values' (which are 'conducive to purposefulness and functionality'), Baxter's 'semantic attractiveness' and Norman's 'behavioural level' in design.
- **Symbolic association** may be defined as the perception of what a product says about its owner or user: the personal and social significance attached to the design. This is related to Crozier's 'response to meaning', Cupchik's 'personal/symbolic response', Lewalski's visual 'Z-values' (which 'fulfil the need to belong and for self esteem'), Baxter's 'symbolic attractiveness' and Norman's 'reflective level' in design. (552)

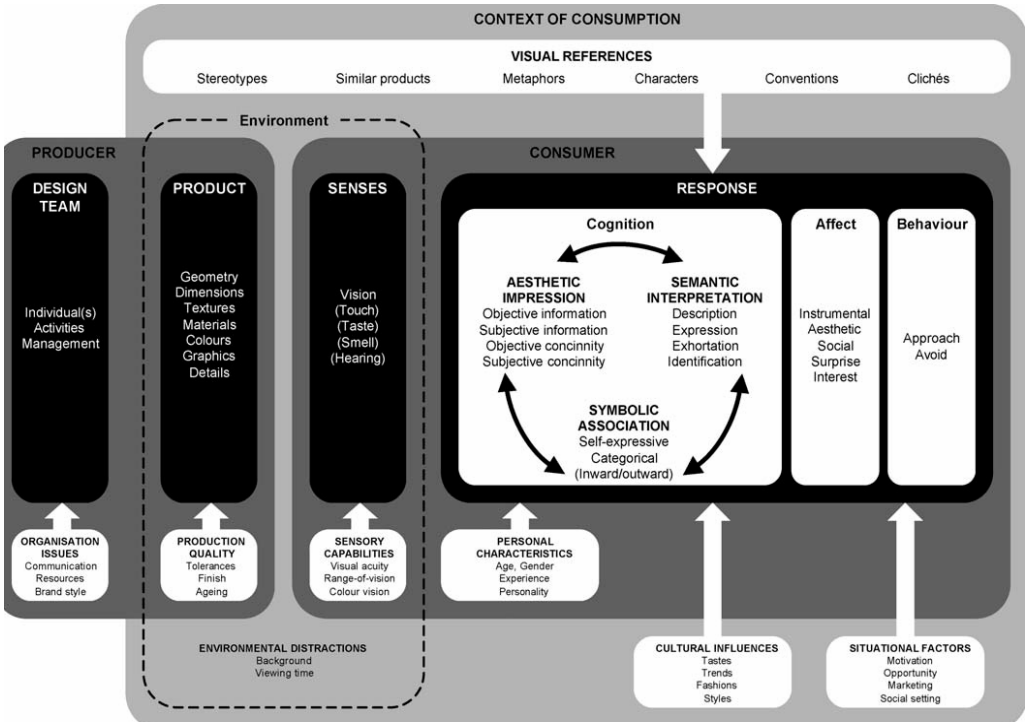

Figure 4.3. Model of consumer response to the visual domain in product design depicted by Crilly et al. (2004)

Note. Reprinted from Note. Reprinted from Crilly Nathan, Moultrie James and Clarkson P. John, " Seeing things: consumer response to the visual domain in product design." Design Studies Vol25 No. 6 November 2004: 547-577.

4.4.2 Affective response

In order to define the affective response, the different definitions of affect have to be considered. According to the dictionary of psychology, Corsini (2002) in terms of psychology, affect is the emotional feeling tone or mood attached to a thought as well as its external manifestations. An early designation of that aspect of the mind that contain emotions and feelings. In terms of affective response to a product design it has been described as the part of 'the consumer's psychological response to the semiotic content of the product' (Demirbilek, O and Sener, B. 2003) According to Norman (2004) affect is the general term for judgmental system whether conscious

or subconscious, closely tied to behaviour. Affect and emotion constitute a complex subject involve all three levels with the most complex emotions dependent upon just how reflective level attributes causes. In Norman's (2004) terms "Reflection" is at the heart of cognitive basis of emotions. The cognitive system makes sense of the world and the affective system is judgmental in information processing.

4.4.2.1 Emotions

In psychological definition according to the dictionary of psychology (Corsini, 2002) emotion is: any mental state characterized by various degrees of feeling and usually accompanied by motor expressions often quite intense. The subjective state may be pleasurable, threatening frightening or some other nature. Emotions are usually directed toward a specific person or event and involve widespread physiological changes such as increased heart rate and inhibition of peristalsis. According to Norman (2004) emotion is the conscious experience of affect, complete with attribution of its cause and identification of its object. Norman (2004,p.10) goes on to state that emotions always passes judgements presenting the human being with immediate emotion about the world : here there is a potential danger, there is a potential comfort this is nice that is bad. Emotions actually alter the parameters of thought. neurochemicals secreted by hormonal glands affecting the brain centres due to reception of these hormones, change the perception and interpretation; therefore meaning, decision making and behaviour. Emotions have been recognised to pervade and swamp the whole organism and its processes (Koffka,1935). Şener and Demirbilek (2003) suggested, thought beliefs and attitudes are automatic response bridges (deep inside our brain) that activate affect, emotions and behaviour in response to situations and events. These thoughts, beliefs have become associated in

experience and knowledge with the situation or the object. Jordan(2000).stated that sometimes a product may provide "pleasure" (in that manner "comfort") through accentuating the emotion already present whilst "pleasure"("comfort") may come from balancing that emotion, providing an emotional benefit. In Crilly et al. (2004) classification the emotional benefits of a product can be interpreted via the cognitive responses contributing to the full range of affective responses where there may be a more direct link between aspects such as aesthetic emotions with aesthetic impressions. Desmet (2003) in Crilly et al.(2004) has proposed five categories for the emotional responses that products may elicit:

- Instrumental emotions (such as disappointment or satisfaction) stem from perceptions of whether a product will assist the user in achieving their objectives.
- Aesthetic emotions (such as disgust or attraction) relate to the potential for products to 'delight and offend our senses'.
- Social emotions (such as indignation or admiration) result from the extent to which products are seen to comply with socially determined standards.
- Surprise emotions (such as amazement) are driven by the perception of novelty in a design.
- interest emotions (such as boredom or fascination) are elicited by the perception of 'challenge combined with promise'(553).

4.4.3 Behavioural response (destination)

The inclination of a consumer to approach or avoid a product basically defines the behavioural response. Approach responses have been associated with further investigation of the product, in order to purchase or evaluate product use. Avoiding a product has been associated with ignoring the product, failure to purchase, product abuse.

4.5 Aesthetic impression

Crilly et al.(2004) referring to Monö (1997), has depicted the aesthetic impression as finding an object visually attractive, elegant or beautiful irrespective of other value judgements. As further explained although positive aesthetic impression is deeply

desired there is an absence of a 'coherent theory with respect to the aesthetic aspect of design'. Referring to Baxter(1995), Crilly et al. (2004) pointed out that the inherent attractiveness of visual form as 'that most illusive and intangible quality'. However Norman (2004) on the other hand has stated that attractiveness is the visceral level phenomenon where the response depends on entirely to the surface look of an object. Furthermore Norman(2004) emphasised that beauty comes from the reflective level (symbolic association by Crilly et al.(2004) description). Beauty has been underlined as a "below the surface" trait and the conscious reflection and experience where influenced by knowledge learning and culture. Norman (2004) has especially underlined that visceral is reactive and purely biological and subconscious. The first impressions are formed the initial impact of a product, about its appearance, touch and feel. It has to feel good, look good. Crilly et al. (2004) have summed certain aesthetic principles and theories that would provide a useful conceptual foundation. In particular, considering the perception of attractiveness as comprising objective and subjective components, and as a balance between opposing factors provides a basis upon which the subject of aesthetic impression might be approached.

4.5.1. Objective and subjective attractiveness

This refers to the *objective property* of the stimuli under consideration. Arnheim (1992) in Crilly et al.(2004) stated that certain lines, proportions, shapes and colours were believed to be inherently attractive. This approach suggests that each object will have an ideal form, which once attained will tend to be considered attractive by everyone. This innate desire for order in visual stimuli resulted in a number of aesthetic principles, which were developed to aid the production of pleasing designs. The principles are commonly referred to as the Gestalt Rules. There are a large

number of these rules, which include an emphasis on symmetry, proximity, similarity, continuance, repetition and closure Koffka(1935)Köhler (1947). Therefore the principles can be accepted as natural (objective).

The consumers' *subjective experiences* contribute to aesthetic impressions. Mostly culture lies under these subjective variances in preferences. Hekkert et al. (2003) has stated that effects of typicality, defined as 'goodness of example', on aesthetic preference Zajonc's, (1968), exposure hypothesis that positive affect increases with repeated un-reinforced exposure and thus familiarity of a stimulus. Bornstein in Hekkert(2003) has stated that both preference for the familiar and preference for the novel have evolved into the behavioural repertoire. Therefore, typicality and novelty are both affective on aesthetic preference therefore impressions.

4.5.2. Aesthetic balance

Positive aesthetic impression has been associated with a balance between two opposing factors in visual perception: *information* and *concinnity* (Crilly et al.,2004) Creating an optimum level of psychological arousal where too little arousal will result in indifference whilst too much will result in displeasure where th's has also been named as "complexity" factor (Karlsson et al., 2003). Consumer's interest has been based on the amount of information composed of both novelty and contrast, (Hekkert et al.2003). On the contrary, concinnity has been related with order and sense perceived in a design. This refers to the typicality in the design increasing the understanding of the product. The information and concinnity perceived in a product has been attributed to both the objective qualities of the product and the subjective experiences of the consumer. In addition to the physical appearance and parameters that comprise the product's visual form, the consumer's familiarity with past

experiences with products, entities and concepts has been stated to influence the aesthetic impression. Therefore, the information and concinnity perceived in a product have been divided into their objective and subjective components as follows:

- **Objective information** may be regarded as the amount of contrast that a design presents against its background and within itself. This is determined by the way in which certain design elements are combined. For example, products which are of a strikingly different colour to the environment in which they are perceived and which utilise a variety of lines, shapes and textures will exhibit a high degree of contrast.
- **Subjective information** may be regarded as the novelty perceived in the design. This is largely determined by the extent to which the product deviates from forms with which the consumer is already familiar. For example, products utilising shapes and lines that are a radical departure from those normally encountered arouse interest due to their novelty.
- **Objective concinnity** may be regarded as the order perceived in the design. This is determined by the application of design principles such as the Gestalt Rules. For example, products exhibiting a high degree of symmetry and orthogonality appear simple, rational and ordered.
- **Subjective concinnity** may be regarded as the extent to which the design appears to make sense to the viewer. This is determined by the consumer's personal, cultural and visual experiences that assist them in understanding the product. For example, products that use design cues from other products, or exhibit a good degree of commonality with existing designs are often easy to comprehend (557-558).

It has been stated that if the information outweighs the concinnity, the product becomes confusing, meaningless and ugly. On the other hand if the product is to close to the mainstream (concinnity) outweighs information, the product becomes simple, dull and boring. Coates in Crilly et al. (2004) states that if and only if when information and concinnity are in balance only then the product becomes engaging and comprehensible therefore leads to attraction.

4.5.3. Design for aesthetic impression

In light of the classification proposed by Crilly et al. (2004) the information and concinnity balance leading to engaging and comprehensible, properties of a product are relevant to comfort. If an automobile seat (also the interior) is to be designed for a common denominator of stimuli, a safe and effective design will be achieved. This is effectively called as "Redundancy", the convention in message, high level of

predictability by Fiske (1990) in communication studies. The opposite in the message on the other hand has been stated to be “entropy” where low predictability and high information content is present. Redundancy can be a tool in the message which the certain design attributes have been already supplied that the consumer has knowledge of. Where as the entropy can be the new design dimension and the interpretation of the interior functions and style. According to Fiske(1990) the good mass communicator is one who is in tune with the feelings and concerns of society at large, common ground. Patterns of thought and feeling influences the design and heterogeneous audience will need a more redundant message. More homogenous audience can afford an entropic design in a seat. In terms of designing a comfortable seat, an attractive seat will work better as products do, however the balance of presentation is a mystery. Especially in terms of the upholstery and the particular layout of textures, patterns and colour. Of course also the whole seat layout can be treated as stimuli of aesthetic impression. Krampen (1989)has indicated under the topic of esthetic affordance(meaning) of design variables such as complexity, incongruity, suprisingness, novelty etc., result from collating the object with our own scale of incongruity or our succession of experiences (in terms of suprisingness, novelty).The degree of stimuli is the ultimate balancing act in terms of aesthetic impressions in design and also seat design. If a comfortable seat affords plain and simple, low textured presentation, than the degree of stimuli should be adopted in order to convey the needed amount. As Coates in Crilly et al. (2004) suggests this can only be achieved by measuring consumer response to products (seats) and correlating perceptions with product features may offer the opportunity to modify designs and closer align them with consumers’ aesthetic preferences.

4.6. Semantic interpretation

Norman (2004) has depicted that this (behavioural) level of design comprises the experience with a product consisting of many facets: function, performance and usability. In this layer of design, performance is denoted as the primary objective whereas appearance is of secondary concern. The objects function as a device; understandability and usability during operation and physical feel are of prime concern. Crilly et al. (2004) made a distinction in order to separate what a product indicates about itself and what it symbolizes about its owner. Semantic interpretation here attempts to describe the partial value assigned to products attributed to their utility where these properties are conveyed to some extent by the visual form of the product. A design's apparent utility and perceived qualities is of focal point. As Crilly et al. denotes this is a narrower definition of product semantics than what has been suggested Krippendorff and Butter. Krippendorff and Butter in Griffin (2001) depict four phases of semantic understanding:

- **Product Identification –** User interprets relevant visual clues to judge the type of object
- **Self-evident Operation –** User handles the object (or alters it's controls) and observes feedback from these actions with various level of success or failure.
- **Explorability of Forms –** User plays with the object to master working knowledge and perhaps devise new applications.
- **Coherence with the Symbolic Context –** User interprets the object in conjunction with others possibly describing the arrangement in terms of personal style, individual expression, social attributes, and aesthetic value.

The use of products in expressing the identity of their owners which pertains to the **"**Coherence with the Symbolic Context" has been separated to the symbolic association topic. Mostly the communication of "use-value" of a product has been explored.

4.6.1 Semantic functions

A products function is the ability of it's to support, enable an activity. If it does not function properly- it bears no use value. In view of this, these "Formal product properties" are clear and fairly unambiguous within the context of design (Jordan, 2000). "Performance" of the product has been defined as "how the well the product does those desired functions". These wellness characteristics are in the views, attitudes and expectations of the people experiencing the product therefore are "Experiential properties" (Jordan, 2000). In this context the visual communication experiential properties of a product with the correct linking and manipulation of the formal properties can be defined as the ultimate goal in semantic function.

In accordance with Mono, Crilly et al. (2004) has summarised the communication of products practical qualities through four semantic functions:

- **Description** refers to the way in which the outward appearance of a product presents its purpose, mode-of-operation and mode-of-use. For example, a grooved handle may suggest the direction in which it is to be turned and indicate how much force will be required. From a product's description, consumers may infer the practical benefits the product will offer and how they must interact with it.
- **Expression** refers to the properties that the product appears to exhibit. For example, modifications to a product's visual form may alter the consumer's interpretation of qualities such as density, stability or fragility. The properties that a design expresses may assist the consumer in understanding how the object should be treated.
- **Exhortation** refers to the requests or demands that a product appears to make of those perceiving it. For example, flashing switches may request that they be switched off. Through exhortation the product may elicit the appropriate actions from the user for correct and safe operation.
- **Identification** principally refers to the extent that the origin and affiliation of a product are conveyed. For example, the manufacturer, product type, product range and specific model may be communicated by text, graphics and design cues. The identification of a product assists the user in understanding the category to which the product belongs (560).

4.6.2 Affordances, constraints and mappings

- **Affordances**, as Krampen (1989) has described, the concept of affordance (by Gibson) refers to the ecological equivalent of "meaning". Gibson in Crilly et. al.

(2004) described as “what physical objects furnish for good or ill”. “To a primitive man each thing says what it is and what he ought to do with it” (Koffka,1935). It has also been defined as demand character**,** invitation character. In order for this perception of an affordance optical information is obligatory to the human (or for that matter animals) such as a physiognomic quality. For the contemporary human, the materials and objects have diversified, in congruence affordances have also multiplied. According to Norman (1988) affordances mean “Psychology of materials and of things the study of affordances of objects. When used in this sense the terms affordance refers to perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used.” (9).Thereby as Krampen(1989) states, surfaces and their layouts exhibit affordances for someone. This results from syntagmatic combination of the syntactic elements surface and medium. Two types of meaning have been indicated to be inherent in surface layouts or designed products: denotative and connotative meanings. The functional meaning is denotative meaning which is the aim of referential semantics: straight connection with context and meaning. The orders are according to functional occurrence. On the other hand the affective affordances possess connotative meanings in design objects by differing features but affording the same surface variables. Affordances may be positive or negative where the human perceives the environment with perceiving itself within it (Krampen, 1989).

- **Constraints** act as limiters or guiders on actions that can be performed by the system or the human . Affordances and constraints mostly work together in that guiding the user to possible and correct type of interaction. The tendency to perform actions can be limited by the perception of obstacles and barriers.

- **Mappings** can be defined as the procedural relationships that the user understands what actions will produce which consequences, corresponding to the behaviour of the system. This mental model of the system can be perceived in the design without operating a device if there are enough cues presented as in to communicate the working of the system. Norman (1988) has explained that purely from visual inspection, the mode of- operation of certain devices can be understood and has stated that visually presenting product functionality can assist consumers in understanding how a product may be operated.

4.6.3 Semantic Categorization

In all of the semantic functions of interpretation, affordances, constraints and mappings communicated by an object the semantic categorisation is a key underlying process(as well as in human information processing and learning) (Athavankar, 1990). Wittgenstein (1979) in Athavankar, (1990) maintained that most natural and intuitively developed categories are often structured around a good example (cognitive reference point) which is treated as a central member and others as its non-central extensions around it. The central member is a key to the understanding of the category and to defining human response to category as a whole. It is a member that metonymically represents the entire category and speaks for it. Comprehension of such a category is largely dependent on the understanding of the semantic devices (perceptual/visual clues) associated with the typical case and typicality gradation that its central position in the categories. Visual clues play a very important role in defining core meaning and in evaluating potential category members. Other examples are compared with this reference and thus evaluated indirectly for the degree of closeness to the core meaning. Lobov(1973) in Athavankar, (1990, p.7)

states that the boundaries remain fuzzy and allow the entrance of new members. Unlike the real world members are not autonomous entities. Mental concepts have a membership gradation with an asymmetric linear structure. New examples due to visible technological innovation, functional and economical benefits can establish bold departures from the central member, thereby cause shifts.

4.6.4 Design for semantic interpretation

The semantic approach to design places emphasis on the consumers' interpretation of the product's function utility and performance qualities (Crilly et al., 2004). For an automobile seat this must be one of the most essential and crucial parameters. In terms of communicative capability of product form (seat) depends on a shared arbitrary code of a design language which enables the elaboration of intended meaning (Fiske, 1990).

In terms of "comfort" the signs can be considered as indexical, having a direct existential connection with its object. These indexical units are combined syntagmatically by rules or conventions (codes). From a paradigm a set from of supporting surfaces and functional features of a seat(side support, seat pan, seat pan bolsters etc.), the message of a particular seat are constructed in to these systems or "Presentational codes" that convey "comfort". In order to supply "comfort" to a degree of heterogeneous community broadcast codes are necessary which is shared by the members of a mass audience (Fiske,1990). Depending on a background of assumptions shared interests shared experience identifications and expectations these codes may be restrictive on the design and if an automobile seat design aims at the lowest common denominator of coding it endangers the design of being dull (Norman 2004).

As Athavankar (1990) emphasised if the nature of **c**ategory membership and categorization strategies are explored the ability to innovate forms, yet maintain or develop visual clues and decisions that potentially prompt the categorization process is feasible. If mental concepts are structured around a core meaning and the semantic space by a "characterized central member" with fuzzy boundaries with graded structure, controlling the level of expressions by initializing visual clues along the gradations is possible. The central member of *"comfortable seat"* is than the key to the understanding of the category and to defining human response to category as a whole. Conscious explorations of this space and the nature of realignment of the boundary by layered structure of meaning is needed in order to create "comfort" and design new comfortable automobile seats. A semantic profile with a presence of high frequency semantic devices would bring the form closer to the central member. The "bundles" of perceptual and functional features enabling prediction of the feeling has to be assimilated. Allo referential semantics may prove to be usefull (Brant,1995).In return this type of intuitive seats, where product semantics is properly applied, have the potential to become more emotionally and psychologically comfortable for users (Şener and Demirbilek,2003).To assist designers, Butter (1989) in Crilly et al.(2004) has suggested a sequence of activities that integrate semantic considerations into the design process. According to this proposal the key stages of the "comfort" process would be:

(1) Establish the overall semantic character of *"comfortable"* that the product should communicate;

(2) List the desired attributes (adjectives, connotations in certain respects according to Osgood, 1957) of *"comfort"* which should be expressed; and

(3) Search for tangible manifestations capable of projecting the desired *"comfort"* attributes through the design medium of the seat (via use of shape, material, texture and colour)

4.7 Symbolic association

According to Crilly et al. (2004) this refers to the socially determined symbolic meaning of a product which evokes 'thoughts, feelings associations which one links to the commodity, or assumes that others must associate with it. As such this bears a culturally agreed meaning of objects which allows a person to communicate their identity through products allowing users to "project a desirable image to others, to express social status and to make visible their personal characteristics" the products become expressive equipment in socio-cultural context of use messages sent by the product(Norman,2004). As Battarbee and Mattelmäki (2002) have stated, products are meaningful because they refer to or carry a meaning given by culture or an individual. Meaning is what connects experience, communication, and reflection: it is that which "circulates" between three known object domains of consciousness-nature(experienced), society(communicated), and our inner states(reflected)-, and which appears in consciousness(Brant, 1995:11) Cultural meanings are understood similarly by the majority of people in the same community (although their preference for these meanings may be different). Personal meanings are constructed through experiences, and products are associated with them. All these products represent or refer to something outside the product itself. According to Norman (2004) these are purely cultural there is nothing practical, nothing biological about the answers (pp87) If Barthes's (1977) in Slater (1997) point of view is adapted, an automobile seat can be treated as a "*sign-function"* where the origin of the sign is utilitarian and

functional. In this case the function of an object can be defined independently of signification. However like the leather seats, if the function mythologizes the idea of luxury it is ideological. Slater (1997) has stated that goods make sense not in terms of their functional place in the order of social practices but rather as sign-values which are semiotically linked in to systems of meaning: aesthetic functional hierarchical and so on. Therefore as coherent with the frame of Jordan(2000) and Crilly et al. (2004) comfort will have at least two more dimensions in terms of psychological response, social comfort and ideological comfort. These pertain to the categorical symbolism and self expressive symbolism in Crilly et al.(2004).

4.7.1 Social Comfort (The categorical symbolism)

Social means relationship with others which projects as relation ships with loved ones friends, colleagues and with like minded people (Norman,2004). The ability to blend in, the integration with the surrounding, this context leads to feeling socially accepted where belonging to a group is definitive. Socially a car could and will enable us to be comfortable or to avoid discomfort in these relationships. The expression of group membership and categorical meanings of a product in this aspect is definitive. The *status* and *rank* recognition which has been associated with furniture is a known example (Jordan, 2000). The perception that the bigger the desk the powerful status within the organization is analogical to the car segmentation and material usage. Typically materials finishing and product decoration have been used as a means of adding status to a product. As Jordan (2000) exemplifies a return to the use of noble materials such as metals and woods as opposed to plastics can add status to a product. Another type of status is concerned with culture-appreciating the right things.

As indicated by Jordan (2000) social comfort topics will pertain to:

- Personality: social self image
- Relationships: social relations
- Social identity: social labelling, belonging to a particular group
- Social behaviour: to conform or to rebel
- Social lifestyles: the message of a particular lifestyle continued by the owner.

Our consciousness is determined by the society we have been born in to not by our nature or individual psychology, where all meanings have a socio political dimension the cannot be understood out of their social context (Fiske, 1990 ,p. 173).

4.7.2 Ideological comfort (The self-expressive symbolism)

According to Crilly et al. (2004) products allow the expression of unique aspects of one's personality, including individual qualities, values and attributes. Named as the self-expressive meanings serving in differentiating the consumer from those that surround them, reflecting the owner's distinction from others, a unique identity of the owner is formed. However on the contrary Fiske (1990) states that ideology is determined by society, not individual unique set of attitudes and experiences.

According to Raymond Williams (1977) in Fiske (1990) ideology can be defined as:

1. A system of belief characteristics of a particular class or group
2. A system of illusory belief- false ideas or false consciousness- which can be contrasted with true or scientific
3. The general process of the production of meanings and ideas (165).

The first definition has been stated to be closer to the psychologist use of the word where ideology refers to the way that attitudes are organized into a coherent pattern.

In terms of the third definition, the social production of meanings are described. Ideology in this way is the source of *second order meanings*. Williams in Fiske

(1990) states that myths and connoted values are what they are because of the ideology of which they are the usable manifestations.

> "The meanings I find in a sign derive from ideology within which the sign and I exist: by finding these meanings I define myself in relation to the ideology and in relation to my society." (172)

As stated by the second definition these ideas may be false such as class ideas imposed to think as if the ideas of ruling class can be accepted as common sense. The class-ideological object is achieved and the ideological work is disguised which are proposed as hegemonic strategies. This is actually "…not the production and distribution of only goods but a lot of ideas and meanings. The economic system is organized in the interests, and the ideological system derives from it and works to promote, naturalize and disguise it." (Fiske,1990 pp177). Ideology works to maintain class domination and the welfare of the system and the system owners. In scope of this big picture, ideologies are used by people as a basis for personal lifestyle choices, for setting goals and aspirations (Jordan, 2000). In the context of products these relate to the tastes, personal aspirations, moral values and the values that product embodies. In terms of aesthetics of a product, ideologies alter the appreciation of aesthetics in products ideological pertains to peoples values. Ideological aspirations of social self image define how people do and would like to see themselves and others to see them (Jordan 2000) these lead to personal lifestyle choices. However fragility of this layer of design has been emphasised by Norman(2004) as fashion, style, mode and vogue and taste are manipulative and volatile. These have been stated as a matter of syntagm (Fiske,1990).

As such, Jordan (2000) has depicted these identifications and aspirations are made use by manufacturers as the basis for building up ranges of products (differing

syntagms). A set of different products that have some common element to them where the range is co-ordinated through out a combination of for example colour form language materials and graphic elements and any of the aesthetic elements. However the vulnerability to variability across culture, experience, education and individual differences have been pointed out by Norman (2004).

4.7.3. Design for symbolic association

In terms of an automobile seat "comfort" design, symbolic association mostly work on historical precedents of the cars brand renown for its qualities , social conventions of status belonging and marketing programmes of the car. An example would be the Rolls Royce, a symbol of wealth as Fiske (1990) has proposed in Pierce`s terms rolls of Royce is an index of wealth but a symbol of the owners social status. Iconic relationships may be active in this level of comfort particularly attributed to visual signs. Communicating the lifestyle, moods and themes that are of interest are very important especially in the interior where the materials used in the seat, the trim and the dash board(console and instrument panel) visual form are associated with specific qualities (Günak et al., 2002). As Crilly et al. 2004 referring to Ashby and Johnson (2002) has suggested the use of wood may evoke images of craftsmanship, metals may be associated with precision and products utilizing polymers are often regarded as 'cheap plastic imitation[s] which holds true also for automobile interiors. The basis for this is the phenomenon of transposing values of properties/qualities from one plane of reality or meaning to another, such as home furniture or a racing car to a passenger car and etc. (Fiske,1990). Natural materials, man made materials all play a role in delivery of a specific message in automobile seat comfort (Fung, W., Hardcastle, 2001). Shared cultural experience is of prime importance. As Crilly et

al.(2004) has indicated, the associations rely less on product appearance where the attitudes become much more important, in our case about the car. Metaphors exploit the truth factor of a natural index and build on it by disguising its indexical nature.

While the harmony of the interior depends on the paradigmatic choice, syntagmatic choices determine the whole taste and fashion. “Narrowcast codes” which are aimed for a specific audience and “elaborated codes” which express abstractions depending on education and training belong to this design level. However there will be trade offs as a value system that rates highly the reinforcement of cultural ties and restricted broadcast codes will find the metaphor of the lowest common denominator offensive elitist and inaccurate.

4.8.Aesthetic, semantic and symbolic interaction

In terms of automobiles especially the symbolic meaning associated with the particular automobile often dominates the aesthetic and semantic aspects of cognitive response. Especially as Crilly et al.(2004) has depicted branding and promotion activities dominate the association of qualities which effect the perception of comfort. However briefly in seat design, in terms of Aesthetic–semantic interaction the importance in seat comfort design is the visual appeal of a design is influenced by the extent to make sense to the viewer. The distinction between the symbolic value associated with a product and semantic interpretation of its instrumental (or utilitarian) value can be fuzzy from time to time but for an automobile seat the utilitarian aspect is of prime importance giving symbolic function a secondary position. The connection-interaction between the perceived aesthetic and symbolic qualities of objects is obvious when consumers want reflection of their taste in

aesthetic preference which is linked to social discrimination (Crilly et al., 2004).Trim and upholstery are the key aspects in these interactions.

4.9 Marketing Considerations: Automobile Classes or Segments

Although these classes and segments do not exist in an official manner, a general consensus is present in the understanding of which car belongs to what segment and class among the Original Equipment Manufacturers (OEM). The most determining aspect of a segment is the dimensions of the vehicle or the utility orientation. The class of vehicles range from "A" class ,"mini" or "budget" extending to "F" being the "luxurious/executive" class where "G" represents any type of "sport/performance" passenger car class (Demir,2002; Bandow and Stahlecker, 2001). Other "passenger" vehicle types form classes which are identified by abbreviations such as the "MPV" (multi purpose vehicle), "SUV" (sport utility vehicle) in certain cases alternatively "4x4" and "CUV" (Cross utility vehicle) in the market.The classification has been displayed in table 4.2.

Most OEMs have either the exact lettering for their models or an analogical numbering system that follows more or less the class/segment/family approach. (http://www.peugeot.com/produits/numerotation/en/) The dimensional considerations of the models, which represent similar values of features, belong to the same class. Various "passenger car" classes may comprise different typologies or body styles of the same model specified as Hatchback, Sedan, Station wagon (sw), Coupé, Cabriolet, Roadster, Saloon, Estate, MPV and etc.

Table 4.2 Automobile Classes or Segments

Category	Lettering	Class	Mercedes-Benz	BMW	Audi	PEUGEOT	CITROËN
Passenger Car	A	Mini	A			107	C1
	B	Small Lower	B	1	A2	207	C2
	C	Lower -Middle	C	3	A3	307	C3
	D	Middle		5	A4	407	C4
	E	Upper-middle	E	6	A6		C5
	F	Luxurious	S	7	A8	607	C6
	G	Sport	SL	M	S TT		
MPV			R			807	C8
CUV		Off-road					
SUV 4x4		Off-road	ML GL	X	Q7		

As stated by Roe (1993), the typology of a vehicle model affects the amount of space available, especially in the rear seat where spatial compromises can be purposely made. In the range of automobile classes, especially in the low cost (economic), compact classes, the automobile are not expected to provide as much accommodation comfort as a family sedan for the rear seat passengers. In context of the need for a vehicle, fuel economy, cost and stylistic considerations may prove more deterministic in design targets, than "comfort" (Roe, 1993). The styling of the interior and the particular concept executed creates the internal atmosphere, in relation to the proposed dimensions in ergonomic considerations. Physical attributes such as windows, screens also influences the mental "sensation of comfort" or a "sense of freedom"(Buti, 2001)

In terms of brands and the particular market segment referred to ranging from high end (expensive) to low end (economic) models, due to the expectancy and the demands of the consumers, the possession of additional design, comfort, convenience and engineering features (i.e. heated mirrors, information technology (IT) systems, side curtain and seat airbags, horsepower (HP) considerations, turbo, compressor, air

conditioning, sunroof, panoramic window roof …etc.) and material appliances in trim and on the dashboard (i.e. wood and aluminium in dashboard trim, leather upholstery in seating…etc.), increase from high volume, low end (economic) models towards the high end (luxurious) models with the increasing cost (Diem, 2001). The marketing strategy of brands is that the high-end models belonging to European luxury car market feature the innovations, being the first sensible segment for introduction of sophisticated systems. On top of this particular models will offer different interior features for the same model of a passenger ranging from standard to optional packages. Manufacturers such as Volkswagen provide for the whole range of models with different feature packages named as “prime line”, “midline”, “ comfort line”, “sportline”, “GTI” denoting the optional packages and their traits. (http://www.vw.com.tr/models/binek/yeni_golf/)

Major important aspect in the design of marketing features in interiors and the ergonomic requirements of these features, is the particular "demographics" of the consumers of the segments. Suppliers and OEM's alike focus on the "lifestyle" and other aspects of the buyers, increasingly trying to identify the needs of the market segment (Ponticel,2003). Increasing buying power of women has reflected upon considerations such as the size, shape and necessities in the interior and component design. The consumer base is highly polarised in a sense that the high-end desires the ultimate quality, performance and craftsmanship whereas the other end a highly "value" oriented profile is present (Snook,2003).

4.9.1 Associations referring to seat comfort in Marketing, Catalogues and Internet

A through scanning of the current catalogues or internet sites of manufacturer brands, present the automobile seat comfort or the concept of general "comfort" either belonging to the topic of interior features of a car or a solitary topic of its own which pertain to certain features of the interior. The interior features of a car are the sub topic of design of the interior in most of the catalogues or internet sites. The comfort features can also be presented as standard or optional package features of equipments or solely interior equipments. Producers such as Volkswagen especially provide in their model ranges a "comfortline" series.

If there is a topic specially provided for the seats, or generally attributed to the comfort of the seat certain main topics appear as:

- adjustable lumbar support
- adjustable seat height
- seat arm rests
- upholstery options provided (mostly leather or some other alternative)
- heated seats
- electrically adjusted seat positions provided memory function
- seat backrest width adjustment(in sports series cars)
- active support seating (dynamically controlled inflatable seats)
- seat options (standard seats, comfort seats, ergonomic seats, sports seats)

Certain producers as Volvo and BMW specially emphasize that different types of seats are provided for different types of models. Especially standard, ergonomic, comfort and sport types of seats are common. One of the most frequently mentioned feature of a comfort seat is its adjustability in multiple directions. However as much

as adjustability is the ability of the seats upholstery application and the surface layout configuration(Volvo), texture and material choices are predominantly underlined most of the time in providing comfort.

4.10 The Instantaneous Influencing Factors in Visual Perception of comfort

The instantaneous factors can be considered to be short term reaction to conditions or a limited amount of attitudes regarding phase(s) in proportion to the average human life span.

4.10.1 Cultural influences

Although culture is a huge and complex entity, we could partially emphasise the contemporary cultural dynamics of a society that will influence the perception. The aspect of cultural agreements on 'what looks good . . . what materials are to be valued . . . what is worth aspiring towards and how aspirations can be reinforced with material goods' is a determinant in preferences especially in automotive culture. Conventions of taste, trends (technological mostly) and transient fashions influence response (Norman,2004). The attitude of the consumer or the "zeitgeist" (or cultural preconceptions) contribute to how designs could be interpreted and the extent to which the styles and current product sign accepted by society.

4.10.2 Personal factors

A customers profile or demographic status which will affect the perception regarding the automobile interior can be summarised as:

- Age
- Gender
- Family members (wife, children and close realtives)

- Occupation (organisational position)
- Income
- chronic injuries or chronic illnesses (physiological characteristics)
- Sensory capabilities (unanticipated message interpretation of the design)
    - visual acuity
    - range-of-vision
    - colour vision
- Experience (previously owned or driven cars)
- Personality (character, status and etc.)
    - variation in the goals, attitudes and standards (for a transient period)
        - consumer's self-confidence
        - social aspirations
        - personal ideologies

As Crilly et al.(2004) suggested, also products are often acquired because they are believed to visually compliment existing possessions.

4.10.3 Situational factors

On top of these the impulsive buying behaviour or manipulation and motivation "activity- rather than goal-oriented" (Crilly et al. ,2004)., most probably will influence, which can be defined as situational factors. The overall impression of the showroom of a particular, perceptions of quality and social value, heritage of a particular brand are major players in altering the perception in general.

"Situational" factors of altering perceptions can be states as:

- brand markings
- adoption of specific design language (Branding)
- product price tag, loaning, leasing opportunities,
- point-of-sale (showroom) architecture, decoration, lighting and vice versa ,
- sales person attending

- competing class and brands
- product predecessors (heritage of the brand)

In the time period of acquisition or consideration "the hedonic quality over its pragmatic quality" of the product can be influential especially if the experience is exhilarating (Crilly et al.,2004). As Jordan (2000) indicated hedonic benefits are those pertaining to sensory and aesthetic pleasures associated with products. Therefore the sought after criteria of comfort may be forgotten for this period of time and a moderate rather than satisfactory characteristic of a seat can be accepted.

4.10.3.1 Distractions in the environment

The time available for viewing determines the amount of information received and the time of processing available. As Norman (2004) pointed out a there is a distinction among the levels of design for the reaction to take effect; time. He suggested that the aesthetic impression (visceral) and semantic interpretation (behavioural) levels are about now, the feelings and experiences while actually seeing or using the product. However he has proposed that the symbolic association (reflective) level extends much longer-through reflection you remember the past and contemplate the future and therefore is about long term relations. Crilly et al. (2004) has also proposed that, aesthetic impressions form immediately where as for semantic interpretation extended observation time would be needed. Therefore interference during these indicated time periods will alter the absorption and processing of information of details.

4.11 Visual References (cues) and Tools of Thought(communication)

As indicated by Crilly et al. 2004 visual references enable the consumer to understand the product by implying concepts, evoking comparison with things (either objects in nature , artefacts, products or living things). The perception is dictated by the visual references whether or not the designers intended these references. Visual references accelerate the assimilation process (Griffin,2001) assisting the viewer in making sense of the Information. These points of reference whether can be named as sense-data, or cues function in the triggering of a mental search (Athavankar, 1990). Visual clues act as codes and so reveal the nature of concepts. Visual semantic devices are the visual clues that link with stored experiences (Athavankar, 1990). Also they activate the "tools of thinking" establishing links or activating the previously established ones, such as in the case of metaphors and metonyms. As Crilly et al. (2004), Şener and Demirbilek, (2003) indicated beyond moderating the aspects of cognitive response, visual references may and will also influence affective response. Crilly et al. (2004) has depicted the *categorisation references* as stereotypes and similar products where references to other styles or entities as metaphors, characters, conventions and cliché's. Şener and Demirbilek, (2003) has depicted emotional response systems or affect programmes as senses, fun, cuteness, familiarity and metonym. The designers intuition of a specific message and understanding compose and produce these messages that inevitably activates a class of similar examples that we have earlier coded structured and labelled with lexical term. The ones considered relative to the aspect of seat comfort will be discussed here.

4.11.1. Stereotypes

Mental concepts are structured around a core meaning (Athavankar, 1990). The example which is closest to core meaning would be used as a cognitive reference to understand the category. As Krampen(1989)puts in relation to the experience, internalized "stereotypes" of types of products, serve as "templates" for the recognition of affordances which we can name in our case of "comfort". The "good example" which bears resemblance to the "good form" of organization of a subjective experience stored in the mind conjures comparisons to the present, both implicitly or explicitly if identifiable cues exist. As stated before the core member metonymically represents the entire category (Athavankar, 1990). Examples are compared with this reference and thus evaluated indirectly for the degree of closeness to the core meaning. Crilly et al. (2004) has denoted the perception of novelty is influenced by stereotypes. As Hekkert et al.(2003) has described people prefer novel designs as long as the novelty does not affect typicality, they prefer typicality given that this is not to the detriment of novelty. The degree of optimal combination of both aspects has been advised. Therefore if a seat has to works on the comfortable level, the scanning of the surface contours (templates) provides the basis for typicality and affording the same surfaces can lead to novel designs. It is important that if a seat does provide comfort to the 95^{th} percentile posturally, the seat may well be associated visually with comfort. As Athavankar(1990) has stated the first successful product by default influences the perceptions and mental concepts of the people therefore once the perceptions are formed, dislodging is not easy.

4.11.2.Similar products

As Athavankar, (1990) has stated the categorization is a key underlying process in human information processing, learning, and communication. If the central member has been fairly well characterized and similar products will act as central extensions around it. Rosch et al.(1976) in Athavankar (1990) further argued that the mind chooses the economical option of neglecting infinite differences between objects by treating non-identical objects as equivalent when;

- these differences are irrelevant to human response
- the behaviour and properties of the objects within the category remain predictable.

This in return means that product close to mainstream directly influence central member. A. Blackler et al. (2003) suggested that prior exposure to products employing similar features help participants in their study to complete the operations more quickly and intuitively. Therefore it can be suggested that prior exposure to products employing similar features will facilitate intuitive decisions on products, "generally correct but not infallible". Retro-nostalgic design cues are especially important in car design, referring to the past and past experiences.

4.11.3 Metaphors (Methaphoric References)

Although Crilly et al. (2004) have isolated the topic of metaphors from characters and conventions, the visual cues in reality are all or by part metaphors, which are related to experience with the environment, with nature, with communication, language and so forth. Metaphors have been defined as "Tools to think" where, they form and shape our understanding of those abstractions and thus enable us to handle them conceptually in our every day lives (Fiske,1990). Metaphors work among

layers of meaning, the principle of association involves transposing values of properties/qualities from one plane of reality or meaning to another (No contiguity, not on the same plane). Transposing takes place between units in a paradigm. The associations are similarities between manifestly different planes therefore by default metaphors "draw upon imagery from external sources" giving the product more descriptive appearance and assist in interpretation and facilitate easy understanding of new concepts (Crilly et al. ,2004). The most basic example given by Jordan(2000) is the speed of an iron being triangular shaped tends to be the indicator of speed of ironing or bulgy sections of a cleaner giving a message of powerful motor in housed by the cleaner. A pronounced waist may hint at femininity, wide legs may indicate stability and broad shoulders may suggest strength (Crilly et al 2004). The associations may be subconscious.

Figure 4.4 Left 2005 ford equator seats, right 2005 Citröen C-sportlounge displaying masculine characteristics

Ref. http://www.carstyling.ru/resources/concept/2005ford_equator_i2.jpg (05.05.2006)
http://www.carstyling.ru/resources/concept/2005citroen_c-sportlounge_28.jpg (05.05.2006)

4.11.3.1 Embodied understanding

This understanding refers to the metaphors in real life derived from bodily experiences (van Rompay and Hekkert, 2004). Embodied understanding has been defined as when human make inferences about products due to the bodily interactions between people and their environments According to Lipps, humans are capable of this projection because humans are subject to the laws of nature like the surrounding physical objects. Empathy, the act of projecting oneself into the object of perception is dominant in making this type of sense of products. According to Lakoff and Johnson, repeated bodily interactions lead to the formation of image schemas determining the way we understand our world. These image schemas make up the basis for our categorizing capabilities and order our perceptual and sensorimotor experiences. something (non-physical, abstract) is understood in terms of something else (physical, concrete) are somehow reflected in products' visual/spatial properties. Designed objects such as chairs embody schemas and so automobile seats may as well .

4.11.4 Characters

The most anticipated type of reference for a product (by humans) would be a character depiction. As Norman (2004) has stated humans are predisposed to anthropomorphize, to project human emotions and beliefs in to anything. In interpretation humans project emotions and empathy. The facial features of humans and other living things are projected on products in order to evoke feelings.

Figure 4.5 Renault Zoe concept seats display "hugging" characteristics
Ref. http://www.carstyling.ru/resources/concept/2005renault_zoe_i02.jpg (05.05.2006)

Especially as Janlert and Stolterman (1997) has emphasised when complex artefacts are encountered,(e.g. cars, boats and etc.) humans become more dependent on characterization, rather than deal with the complexities of the products functions. Humans use characters as mental tools to handle complex realities reducing effort in handling products (just as humans) offering a first bridge between physical appearance and function (behaviour). Car design is known to rely on the idea that the buyers recognize a certain number of established, standard characters (Janlert and Stolterman, 1997). The most vital aspect of this planting has been emphasised as the desired overall character needed to be conveyed without unintentionally introducing clashing symbols. The idea that there are relatively stable relations between certain appearances and certain characteristics has lead to a complete character theory Janlert and Stolterman(1997) has proposed that a character is made up of unity of characteristics (just like the concept of comfort) where one character combines several characteristics, not as a simple collection, but with related characteristics integrated into a relatively coherent whole. Successes and failures build up the ground for ascribing a certain character to a product , As long as the users finds or invents new useful characteristics the character modelling process continues.

A character can be made use of in many ways by a human being (Janlert and Stolterman(1997). *Generating expectations:* as increasing anticipation of behaviour (hidden) of the product with perceivable appearance *generating explanations*: a tool for prediction of behaviour, *context for interpretations:* a way of reasoning due to couplings of certain characteristics, s*chema for normal functioning:* how the product is ought to behave.

4.11.5 Conventions

Conventions are socially agreed rules upon which the meaning of visual signs have been established. In terms of products, **a non-functional metaphor (or analogy)** will convey about the manner in which to interaction with it (janlert and stolterman,1997)**.** Analogies act as "cognitive support". An exemplary study can be portrayed by transition of a comfortable office chair to a car seat by Johnson controls "LEAP".

Figure 4.6 The morphological analogy developed from Herman millers Aeron office chair to "LEAP" by Johnson Controls Inc.
Ref. http://www.steelcase.com/na/images/fab9d0b7048449af9705c7c4e4c04748.jpg (03.10.2006)

4.11.6 Cliché's

Cliché's can be thought of too much conventional cues on a variety of products However conventionalization involves a lowering of quality (Fiske,1990). "Lack of significant thought" about the design of a product as Crilly et al.(2004) has described due to the success of the original iMac, 'many other colorful, transparent products. transparent color had become a cliche´'. An example of such seat made by recaro has been displayed in figure 4.6

Figure 4.7 Rinspeed zazen seats made by Recaro

Ref . http://www.germancarfans.com/photos/3060215.002/1014.jpg (08.06.2006)

4.11.7 Tangible Elements of Visual Communication

In accordance with Griffin (2001) and Jordan (2000) the possible tangible elements of visually communication through design are:

- contouring,
- contrasting materials,
- directional orientations (e.g., through lines),
- spatial relationship(s) between functional elements (e.g., buttons) might communicate hierarchy, sequence, or direction,
- accentuation vs. concealment

- material properties (volume/displacement)
- surface orientation,
- texturing
- colour (s): both physiological and emotional information presentation. Not only by emotion physical processes of wave lengths play an active role on creating impressions. E.g. red is found oppressive in car interiors .
- Harmony of the interior: a combination of colours affects perception
- shape(s): basis for metaphors and analogies
- proportion and relation,
- spacing (pacing),
- unity/ fragmentation.
- product graphics
- Production quality

    - design tolerances
    - surface finish
    - ageing of products over time
    - Sensorial design, "Touch design" and other research schemes carried out by manufacturers especially aim at this by blind and visual testing of materials for usage in upholsteries and trim (Masson, 2005). Material properties conjure the perceived quality of interiors of cars.

4.11.7.1 Styling

As Krampen(1989) has denoted if the functions remain constant and different layouts affording these functions can be supplied, "style" has been imposed on the object. According to Chen and Charles(1997), a style can be expressed through a unique composition and configuration of *Formal elements* where stylistic features represent "those psychological qualities that we feel." Dondis (1973) in Chen and Charles(1997), has told that for visual communications: "Style is the visual synthesis of the elements, techniques, syntax, inspiration, expression, and basic purpose." As a

design problem can be solved by many different ways, connotation arises which is styling. Smith in Chen and Charles (1997) suggested that differences in styles arise from changes or differences in constituent elements and relationships among them. If there are no different components and no distinguishable change(s) in relationships among them, the style can not be differentiated from others. Also style can be shared among various objects and can coexist among different domains**.**

4.12. Conclusion

We rely on our communicative abilities and experiences in order to obtain and sustain what we want in our lives. As stated earlier upon confrontation with the product, a complex entity for most, people tend to develop and rely on, an overall feeling about the product forming a certain attitude about the product, an intuition just like encountering first time another human. Janlert and Stolterman (1997) pointed out that the basic abilities as human beings which have evolved in dealing with each other and with things in their environment, apply also in dealing with products. After all, a person can "comfort" another. The designer has to make clear what should and how it should be communicated through the product. Messages are being sent through products via stimulus in colour, shape, form, and texture in, whether intuitively or intentionally meaning is delivered. In order to create a successful design of comfort, the designer should strike a balance in creating the intended profile, purposefully use cues for the intended message. The dangers of relying solely on intuition and anecdotal evidence have been well acknowledged in justify a product's visual appearance. If an overall message is to be conveyed, the completeness, coherence of characteristics and attributes are of prime importance. In relation to these objectives, the development of visual features should aim at a

holistic profile of intended feeling, intuition and identity for the user. The relation between function and surface appearance, performance and formal properties, should be defined as clearly as possible, in order to provide a guided visual interaction. The three levels of product design (in relation to the three levels of processing) have been well depicted in visual domain. These three components rendered in any design will interweave both emotions and cognition (Norman, 2004). Creation of “comfort” is no different. Whether called taste, harmony of visual stimuli and etc. the first level of design being the balance between novelty and typicality, innovating while preserving a certain amount of typicality has been underlined. For the second level, as Griffin (2001) has emphasised the refinement of the design by locating the key semantic clues (elements) in the areas where users in interaction naturally look to on encountering new products, functioning in “making things visible” and comprehensible. On top of these, in the third level, the associations with the product at different degrees in accordance with individuals’ social and ideological identity disposition; creating ones own perceived being, role and mission, will amplify or dampen the perception of the products message (profile). The successful design has to excel at all levels where the design requirements for each level differ widely (Norman, 2004).

Actually objects isolated in the real world exist in the overlapped and tangled links, which form their identity in the conceptual world of the human mind. In its own sense comfort is a learned mental concept. It is influenced by the object and activities of the real world, experience and so forth with the automobile. The sensation of visual comfort has been attributed to the shape, form and colour and "perceived space" of the vehicle interiors by professionals and researchers alike, which encompasses a harmonious and ambient feeling (Buti, 2001). In terms of the seat, the

styling will act as the basis for an interpretation whether reinforcing or decaying an impression of comfort and the forming qualities of comfort. The existence of a coherent unity of characteristics, “comfort” has to apply across different functions and qualities of the seat. It is important that a product’s appearance is congruent with other sensory aspects of design as “the product form that the eye sees creates in the observer, expectation of what the other senses will perceive” (Crilly et al.2004).

CHAPTER 5

FIELD STUDY

In order to explore the intrinsic dimensions of automobile seat comfort and adopting the view that any cognitive response to product appearance or visual domain design may embody three main categories (aesthetic impression, semantic interpretation, symbolic association), an investigation has been carried out. The objectives of this study were to:

- Explore the potential dimensions of visual attributes of the design regarding comfort.
- Quantify the contribution of each dimension to the overall perception of the customers.
- Investigate the effect of gender (significance) on the visual perception of comfort.
- Investigate the effect of age (significance) on the visual perception of comfort.
- Identify the users' attitudes and concerns in comfort design of automobile seats.

The studies 'in literature have also followed semantic methods in order to asses automobile interiors as in Karlsson et al.(2003), Zhang and Shen(1999), Tanoue et al. (1997) and Nakada(1997).Therefore this study focused on the semantical meaning due to the objectives of the study; which basically is the relation of signs to their siginificates.

5.1 Method

Osgood et al. (1957) has depicted that the assumption whenever a sign is received (decoded) distinctive meditational process or states occur in the organism.

The basis of the theory behind the SD is that words represent things because they produce in human organisms some replica of the actual behaviour towards these things as a mediation process Inherent in this view, the meanings which different individuals have for the same signs varies to the extent that their behaviours toward the things signified have varied. The reason for this has been stated as during the composition of the representational process-(the meaning of the sign entirely depended upon the nature of the total behaviour occuring during the sign is being established.The method relies upon the fact that the essential sameness of human organsims and the stability of physical laws, will provide a quite constant meaning of the most primary perceptual signs across individuals (e.g. apple).The variation in the meaning has been attributed to the fact that representational process of a sign depends entirely upon the samples of other signs with which they occur. Therefore this meaning of a sign has been accepted to be a complex reaction which is divisible into some unknown but finite number of component

Questionnaire Design

The semantic differential is a standardized procedure for eliciting a carefully devised sample of a subject's placement of a word on a continuum, developed by Osgood et al. (1957). to assess affective meaning of automobile seat comfort, scales made of polar adjectives on a series of 7 point Likert scales have been devised. Evaluations have been done on product samples and the estimating adjective antonym pairs to express impressions have been taken from magazines, catalogues, and derived form conversations with users on automobile seat comfort. Some of these words are

adjectives, nouns, verbs and jargon. The scales provide quantitative measurements on different adjectives. By averaging across subjects the aim is to provide a stable estimation of the comfort concept as the impressions created by a given object differ from subject to subject. The semantic differential (SD) method enables the derivation of common semantic range of people's perceptions and the perception of common values regarding the concept of comfort (Ishihara et al.,1997; Osgood, 1957).

The 14 adjectives were chosen on the following basis due to statistical needs:

- The adjectives should have high loading in the factor and low in other factors,
- The adjectives should not show tendencies to float between factors,
- Inside each factor variables were chosen that fulfilled the sought category (aesthetic impression, semantic interpretation, symbolic association). Synonyms have been avoided as much as possible.

The 15th scale was constructed in order to asses the overall impression of visual comfort which was to be rated after the first 14 scales. The appearance of the administered questionnaire's first page has been displayed in figure 5.1.

Participants – 28 passenger car drivers participated in the study. The demographic information of the subjects is listed below:

Participants	14	14
Age range	23-29	30 and up
Male	7	7
Female	7	7

The selection criteria of participants were that each participant had to have at least 3 years of driving experience regardless of the segment of the car owned. All participants were drivers of lower to upper class segment cars and were university graduates. None of the participants used a Volvo previously and were specifically chosen for that purpose. The participants were mainly from the univesity .

Procedure

The study was conducted at the Volvo showroom of Grup Volvo without altering the conditions of the showroom.

	KONFOR (COMFORT)		
REPULSIVE	İTİCİ	ÇEKİCİ	ATTRACTIVE
UGLY	ÇİRKİN	GÜZEL	BEAUTIFUL
PLAIN	TEK DÜZE	CANLI	LIVELY
NARROW	DAR	GENİŞ	WIDE
HARD	SERT	YUMUŞAK	SOFT
UNCOMFORTABLE*	RAHATSIZ	RAHAT	COMFORTABLE*
UNRELIABLE	GÜVEN	GÜVEN	RELIABLE
LOOSE	VERMEYEN VÜCUDU KAVRAMAYAN	VEREN VÜCUDU KAVRAYAN	EMBRACING
CHEAP	UCUZ	LÜKS	LUXURIOUS
SIMPLE	BASİT	SOFİSTİKE	SOPHISTICATED
ANGULAR	KÖŞELİ	YUVARLAK	ROUNDED
STATIC	DURAĞAN	DİNAMİK	DYNAMIC
DULL	SIKICI	İLGİNÇ	INTERESTING
COLD	SOĞUK	SICAK	WARM
CRUDE	KABA	ZARİF	ELEGANT

	GENEL OLARAK (OVERALL)		
UNCOMFORTABLE	KONFORSUZ	KONFORLU	COMFORTABLE

Figure 5.1 The antonym pairs as presented in the questionnaire

* The English translations have been presented, however comfortable in this sense does not provide the actual Turkish meaning..

Section One:

The appearance of each of the three Volvo model's seat designs consisting of S40, S60 and S80 using 15 semantic differential scales were rated, see Figure 5.2.

The visual assessment of the seat was done prior to sitting and the expected overall comfort was rated with the SD scales. After completion of the first scales, the participant was seated to the interior of the car. All the antonym pairs were known

common Turkish words. The participants were given a run through by the test leader in order to understand the method of rating accurately. The run through procedure has been supplied in the Appendix A and participants were convinced about the method of continuous scaling. If a participant asked about the meaning of a word in the questionnaire the test-leader by no means provided an own interpretation of the word. It was indicated that there were no right and wrong answers and participants were encouraged to think of the meaning he/she put into the word in the context of visual perception of automobile seat comfort.

Figure 5.2 Left to right the Volvo S40, S60 and S80 automobile driver seats which were present in the automobiles.
Ref.(http://www.volvocars.us/models/s40/FeaturesOptions.htm)(03.07.2006)

Section two:

After the visual rating of the perception, the participant was asked to sit in the car, adjusting the seat according to his/her own preferences in order to accommodate the physical needs. After the door was closed, the participant was administered the second page of the questionnaire where the picture of the seat and a picture of the seat with a manikin sitting were present, consisting of a body part indicator of any discomforting area and the overall comfort feeling scale in this time duration. Two

open ended questions and a 7 point Likert scale which presented the overall sitting comfort are present in this page (appendix A). The two open ended questions were in relation to the pictures presented and asked:

- **Question 1:** During the examination of the seat, which area(s) of the seat caught your attention or you looked at intentionally?
- **Question 2:** Following the 15 minutes duration that you have been seated, were there any area(s) that uncomforted/ comforted beyond your expectations?

In relation to the questions the participants were asked to mark the areas related with their answers or directly mark areas in relation to the first question.Following the 15 minutes duration (due to Porter et al.(2001) studies regarding showroom comfort period) the participants were asked to rate the 7 point Likert scale. On the request by the test administrator or the will of the participant, further notes were taken on whether the perceived expectations of the seat attributes were met or not.

The dimensions and the interior of the cars used in this study have been presented in the following figures 5.3 – figure 5.5, rated by the participants.

Limitations of the Study

The antonym descriptor pairs used for the study have been limited to 14 as more descriptors statistically necessitate more participants. Another important limitation in the study was that as the study was conducted in the showroom, road trials to test the riding comfort of the seat could not be carried out. Test ride vehicles of the models were not available for carrying out extended trials of 2 hours, suggested by Porter et al.(2001). A major factor in the study was that the upholstery of the three different seats were all leather however the colour and quality varied amongst the seats.

Figure 5.3 The Volvo S40 automobile dimensions (mm) and interior appearance

5.2 Results

Factor Analysis (Principal component analysis)

Responses collected using semantic differential (SD) scales were submitted to a Factor Analysis with Varimax rotation in order to identify the key design factors of automobile seat comfort and the correlation between these design factors and customer preference. The main applications of factor analysis (named also as Principal component analysis (PCA)) serve to reduce the number of variables and detect structure in the relationships between variables, classifying the variables in to components. The extraction of principal components amounts to a variance maximizing (varimax) rotation of the original variable space.

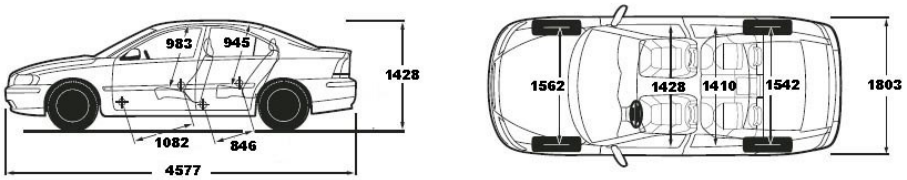

Figure 5.4 The Volvo S60 automobile dimensions (mm) and interior appearance

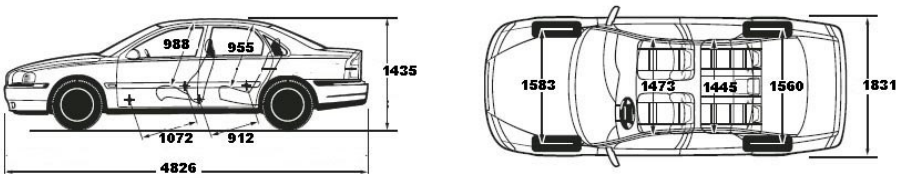

Figure 5.5 The Volvo S80 automobile dimensions (mm) and interior appearance

The rotation aims to maximize the variance (variability) of the "new" variable (factor), while minimizing the variance around the new variable. The correlations are the factor loadings. An original set of correlated variables are transformed into a new set of uncorrelated variables, which are linear composites of the original variables structure. In this study three factors were identified due to PCA in table 5.1. The rotated component matrix has also been tabulated in table 5.2.

Table 5.1 Un-rotated PCA component matrix (N=84) and variable list.

Component Matrix[a]

	Component		
	1	2	3
VAR00001	,851	-2,14E-02	-9,20E-02
VAR00002	,811	,156	-,126
VAR00003	,842	-,274	-,169
VAR00004	,806	-5,95E-02	-,276
VAR00005	,402	,479	,428
VAR00006	,776	,150	7,276E-02
VAR00007	,863	-,101	-2,32E-02
VAR00008	,800	-,313	-,134
VAR00009	,698	,255	-,374
VAR00010	,326	,699	-,314
VAR00011	,419	,524	,330
VAR00012	,622	-7,22E-02	,389
VAR00013	,739	-,206	,388
VAR00014	,754	-,303	,186

Extraction Method: Principal Component Analysis

a. 3 components extracted.

VAR1	itici_:_:_: _:_: _:_çekici
VAR2	güven vermeyen _:_:_: _:_: _:_güven veren
VAR3	tek düze_:_:_: _:_: _:_canlı
VAR4	basit_:_:_: _:_: _:_sofistike
VAR5	sert_:_:_: _:_: _:_yumuşak
VAR6	rahatsız_:_:_: _:_: _:_rahat
VAR7	çirkin_:_:_: _:_: _:_güzel
VAR8	sıkıcı_:_:_: _:_: _:_ilginç
VAR9	ucuz_:_:_: _:_: _:_lüks
VAR10	dar_:_:_: _:_: _:_geniş
VAR11	köşeli_:_:_: _:_: _:_yuvarlak
VAR12	vücudu kavramayan _:_:_: _:_: _:_vücudu kavrayan
VAR13	soğuk_:_:_: _:_: _:_sıcak
VAR14	kaba_:_:_: _:_: _:_zarif

According to these findings due to statistical processing of the data, in spite of careful selection of antonym pairs in order to assess the hypothesized three factors of visual domain design of comfort, only a major first factor has been found. The correlation matrix depicted that the antonym pair variabiles of 1,2,3,4,6,7,8,13 an 14 form the first factor.

Variables 5, 11 shows a tendency to from a second factor, where the third factor is composed of 9th and 10th variable. In view of this analysis it can be interpreted that

Table 5.2 Rotated PCA component matrix with Varimax rotation (N=84).

Rotated Component Matrix[a]

	Component		
	1	2	3
VAR00001	,769	,220	,305
VAR00002	,655	,280	,437
VAR00003	,883	1,713E-02	,180
VAR00004	,760	4,579E-02	,387
VAR00005	,104	,732	,169
VAR00006	,612	,413	,291
VAR00007	,812	,231	,209
VAR00008	,861	6,562E-03	,117
VAR00009	,526	,111	,635
VAR00010	-1,18E-02	,274	,786
VAR00011	,105	,690	,269
VAR00012	,555	,470	-,117
VAR00013	,721	,436	-,172
VAR00014	,793	,235	-,101

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 11 iterations.

the questionnaire has mainly measured the attitudes of the participants in general which is aesthetic preference and taste as depicted in component 1. However this can be attributed to the fact that the participant sample is small and with higher participant numbers it may be possible to extract three independent factors. If we were to interpret the result of this factor analysis according to the trend in formation of the components, factor 1 is mostly formed of impressions where factor two consists of floating variables of the first. However the higher correlated variables have been variable 5 (0,732) (hard_:_:_: :_: :_soft) and variable 11 (0,690) (angular, _:_:_: :_: :_rounded) for the second factor. And for the third factor variable 10 (0,786) (narrow_:_:_: :_: :_wide) and variable 9 (0,635) (cheap _:_:_: :_: :_luxurious) were highly correlated. In relation to these findings, strictly not speaking statistically due to the floating variables, a certain semantic interpretation factor can be felt. The participants may well assess the use value of a seat visually associating

hard/soft qualities with roundedness or pointed shapes. Also a dimensional assessment may be possible by the participants due to the third factor as tight/spacious has been correlated with cheap/luxurious mostly, which can be an indication of both use value of the space and wealth regarding a symbolic value of the seat in relation to the car interior environment. In order to be statistically safe for 14 variables 140 subjects has been stated to be obligatory by statistical references. Therefore in order to assess the data properly due to the finding that a general attitude has been measured towards automobile seats, multivariate tests have been carried out.

Correlations of variables with Overall Impression of Comfort

In order to provide an insight of which variable effects the overall impression and explain the components of overall comfort impression (Variable 15) correlation process was applied to the data. The resulting correlation coefficients have been displayed in Appendix B. In terms of Pearson correlation coefficients, the correlations significant at the 0.01 level (2-tailed) have been reported which are highly significant. The correlations of other variables significant at the 0.05 level (2-tailed) with overall impression of comfort was variable 5 (hard_:_:_: :_: :_soft) and no significant correlations were found with variable 10 (narrow_:_:_: :_: :_wide). The antonym pairs have been reported here in Turkish, as English translations were presented earlier. Due to these correlation coefficients displayed in table 5.3. in descending order, we can state that the overall impression of comfort is highly affected by the overall impression of *reliable, comfortable , beautiful, elegant* and *attractive* design in automobile seat design, being the first five variables. However

the correlation of these impressions with tangible design parameters is obligatory for proper guidelines in design to propose definitive design guidelines.

Table 5.3 Pearson correlation coefficients of the SD variables with overall impression of comfort, the correlations are significant at the 0.01 level (2-tailed)

Variable	Semantic Scale	Pearson correlation P<0.01 (2-tailed)
VAR2	güven vermeyen _:_:_: :_: :_güven veren	,764
VAR 6	rahatsız _:_:_: :_: :_ rahat	,701
VAR 7	çirkin_:_:_: :_: :_güzel	,680
VAR 14	kaba_:_:_: :_: :_zarif	,666
VAR 1	itici_:_:_: :_: :_çekici	,651
VAR 13	soğuk_:_:_: :_: :_sıcak	,648
VAR 8	sıkıcı_:_:_: :_: :_ilginç	,645
VAR 3	tek düze_:_:_: :_: :_canlı	,579
VAR 4	basit_:_:_: :_: :_sofistike	,573
VAR 9	ucuz_:_:_: :_: :_lüks	,527
VAR 12	vücudu kavramayan _:_:_: :_: :_vücudu kavrayan	,506
VAR 11	köşeli_:_:_: :_: :_yuvarlak	,259

Multivariate Analysis

Within-Subject (Repeated Measures) Designs

As the same test was administered to the same subjects repeatedly over a period of time or under varying circumstances the multivariate analyses concurs with the description of within-subject (Repeated Measures) Design. In essence, we are interested in examining differences within each subject to the three different seat

designs. The seat designs have been the multiple dependent variables in the test design. Multivariate measures of association take into account not only the relationships of the predictor variables with responses on the dependent variables, but also the relationships among the multiple dependent variables. These measures of association provide information about the strength of the relationships between predictor and dependent variables independent of the dependent variable interrelationships. As depicted in the factor analysis, a general preference or attitude (response) has been rated by the participants. Therefore the means of the scores of 14 variables across the participants have been calculated and subjected to the multivariate analyses in order to investigate the possible interactions of seat design, gender and age. The output of SPSS regarding the multivariate test analysis and Tests of Within-Subjects Effects has been displayed in table 5.4 and table 5.5.

Table 5.4 Multivariate Tests

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
FACTOR1	Pillai's Trace	,501	11,552[b]	2,000	23,000	,000	,501	23,104	,986
	Wilks' Lambda	,499	11,552[b]	2,000	23,000	,000	,501	23,104	,986
	Hotelling's Trace	1,005	11,552[b]	2,000	23,000	,000	,501	23,104	,986
	Roy's Largest Root	1,005	11,552[b]	2,000	23,000	,000	,501	23,104	,986
FACTOR1 * CINSIYET	Pillai's Trace	,009	,101[b]	2,000	23,000	,904	,009	,202	,064
	Wilks' Lambda	,991	,101[b]	2,000	23,000	,904	,009	,202	,064
	Hotelling's Trace	,009	,101[b]	2,000	23,000	,904	,009	,202	,064
	Roy's Largest Root	,009	,101[b]	2,000	23,000	,904	,009	,202	,064
FACTOR1 * YASGRUP2	Pillai's Trace	,203	2,934[b]	2,000	23,000	,073	,203	5,868	,516
	Wilks' Lambda	,797	2,934[b]	2,000	23,000	,073	,203	5,868	,516
	Hotelling's Trace	,255	2,934[b]	2,000	23,000	,073	,203	5,868	,516
	Roy's Largest Root	,255	2,934[b]	2,000	23,000	,073	,203	5,868	,516
FACTOR1 * CINSIYET * YASGRUP2	Pillai's Trace	,026	,302[b]	2,000	23,000	,743	,026	,603	,092
	Wilks' Lambda	,974	,302[b]	2,000	23,000	,743	,026	,603	,092
	Hotelling's Trace	,026	,302[b]	2,000	23,000	,743	,026	,603	,092
	Roy's Largest Root	,026	,302[b]	2,000	23,000	,743	,026	,603	,092

a. Computed using alpha = ,05

b. Exact statistic

c.
Design: Intercept+CINSIYET+YASGRUP2+CINSIYET * YASGRUP2
Within Subjects Design: FACTOR1

Table 5.5 Tests of Within-Subjects Effects

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
FACTOR1	Sphericity Assumed	8,059	2	4,029	10,387	,000	,302	20,775	,983
	Greenhouse-Geisser	8,059	1,952	4,128	10,387	,000	,302	20,278	,981
	Huynh-Feldt	8,059	2,000	4,029	10,387	,000	,302	20,775	,983
	Lower-bound	8,059	1,000	8,059	10,387	,004	,302	10,387	,871
FACTOR1 * CINSIYET	Sphericity Assumed	9,269E-02	2	4,634E-02	,119	,888	,005	,239	,067
	Greenhouse-Geisser	9,269E-02	1,952	4,748E-02	,119	,883	,005	,233	,067
	Huynh-Feldt	9,269E-02	2,000	4,634E-02	,119	,888	,005	,239	,067
	Lower-bound	9,269E-02	1,000	9,269E-02	,119	,733	,005	,119	,063
FACTOR1 * YASGRUP2	Sphericity Assumed	2,084	2	1,042	2,686	,078	,101	5,373	,508
	Greenhouse-Geisser	2,084	1,952	1,068	2,686	,080	,101	5,244	,501
	Huynh-Feldt	2,084	2,000	1,042	2,686	,078	,101	5,373	,508
	Lower-bound	2,084	1,000	2,084	2,686	,114	,101	2,686	,350
FACTOR1 * CINSIYET * YASGRUP2	Sphericity Assumed	,220	2	,110	,283	,755	,012	,567	,092
	Greenhouse-Geisser	,220	1,952	,113	,283	,749	,012	,553	,092
	Huynh-Feldt	,220	2,000	,110	,283	,755	,012	,567	,092
	Lower-bound	,220	1,000	,220	,283	,599	,012	,283	,080
Error(FACTOR1)	Sphericity Assumed	18,620	48	,388					
	Greenhouse-Geisser	18,620	46,851	,397					
	Huynh-Feldt	18,620	48,000	,388					
	Lower-bound	18,620	24,000	,776					

a. Computed using alpha = ,05

Tests of Within-Subjects Effects

In relation to the results due to the General Linear Model (GLM) Repeated Measures procedures the overall impression of the seat design (designated as FACTOR 1) was significant , multivariate $F(2, 23) = 11{,}552$, $p < .005$, partial Eta squared = .501. This means that there is a significant difference in responses of the subjects to the three different seats. However there were no statistically significant interactions among other factors (main effects). In GLM there are no between-subjects factors or covariates due to the analysis method as the observations are not independent.

Table 5.6 Tests of Within-Subjects Contrasts

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	FACTOR1	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power[a]
FACTOR1	Linear	6,642E-02	1	6,642E-02	,150	,702	,006	,150	,066
	Quadratic	7,992	1	7,992	24,100	,000	,501	24,100	,997
FACTOR1 * CINSIYET	Linear	7,662E-02	1	7,662E-02	,173	,682	,007	,173	,068
	Quadratic	1,607E-02	1	1,607E-02	,048	,828	,002	,048	,055
FACTOR1 * YASGRUP2	Linear	,628	1	,628	1,413	,246	,056	1,413	,208
	Quadratic	1,457	1	1,457	4,392	,047	,155	4,392	,521
FACTOR1 * CINSIYET * YASGRUP2	Linear	2,050E-02	1	2,050E-02	,046	,832	,002	,046	,055
	Quadratic	,199	1	,199	,601	,446	,024	,601	,116
Error(FACTOR1)	Linear	10,660	24	,444					
	Quadratic	7,959	24	,332					

a. Computed using alpha = ,05

Tests of Within-Subjects Contrasts

GLM uses a set of orthogonal polynomial transformations. These three polynomial transformations represent the linear and, quadratic effects. Each is a separate estimate of the main effect. As displayed by the output in table 5.6, a significant quadratic relationship (fits a second-order polynomial function to the points in the 3D scatter plot) between the three seats is present. However there were no other statistically significant interactions (An interaction is the variation among the differences between means for different levels of one factor over different levels of the other factor).

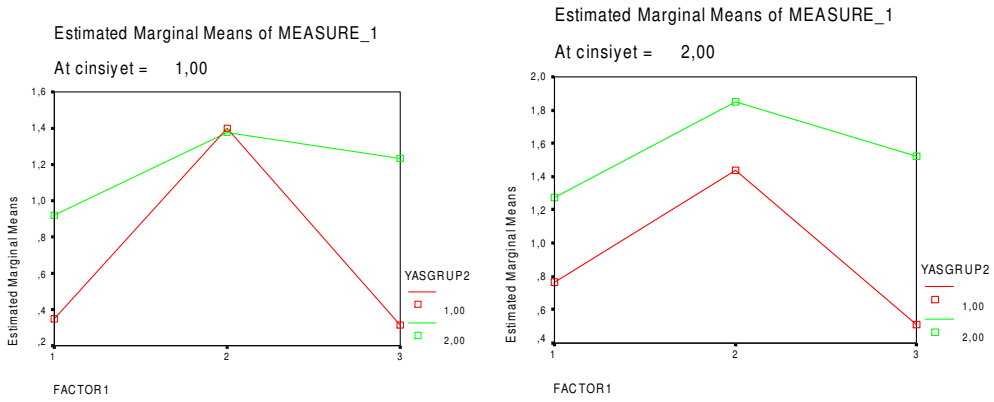

Figure 5.6 The difference in attitude according to age groups on gender.

Although not statistically significant, graphs of the statistics on different levels of the factors depict certain viable trends among the subjects. In terms of gender, male participants between the age of 23 - 29 are much more specific in their positive attitude on the S60 automobile seat (figure on the left). The female participants show a much more positive attitude towards the seats however the female participants ages 30 and up show a very fond attitude towards S60 where S80 seat also scores very

high. In terms of these result it can be suggested that young men prefer highly the S60 where older man display a tendency towards S80 also. This can be attributed to the fact that S80 has greater dimensions of interior space and favorable. Young male participants could prefer the same dimensions but a more compact and tighter seat.

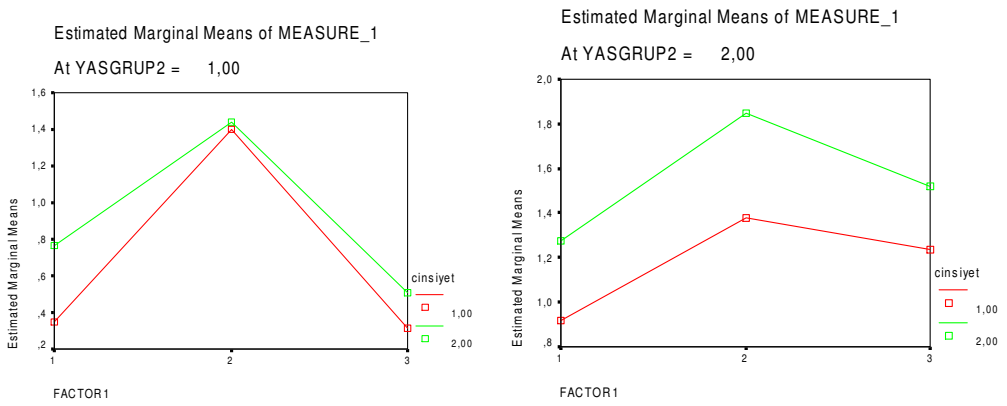

Figure 5.7.The difference in attitude according to gender on seat design displayed

In terms of gender acting on preference of seats displayed on different age groups as displayed in figure 5.7, it can be directly stated that young participants regardless of gender have consistent high positive attitude towards the S60, where as in the ages 30 and up group female participants have significantly rated higher all of the seats than male participants. It is also evident that in relation to the figure… the participants in the 23-29 age range show agreement for the S60's seat scores and little variance for the other two seats. However in the 30 and up data the trend of females rating higher on all three of the seats is evident. The consistency of preference of the participants in the age range 23-29 can be attributed to the fact that young drivers liked the S60's seats due to the features which encourage more dynamic driving and bolder features with bigger saw lines of sportiness due to the comments. However no interpretation is possible on why the females in the 30 and

up age group, liked the seats more than the males of the same age group. Figures 5.8 through 5.10 displays the difference in ratings for each of the three seat designs.

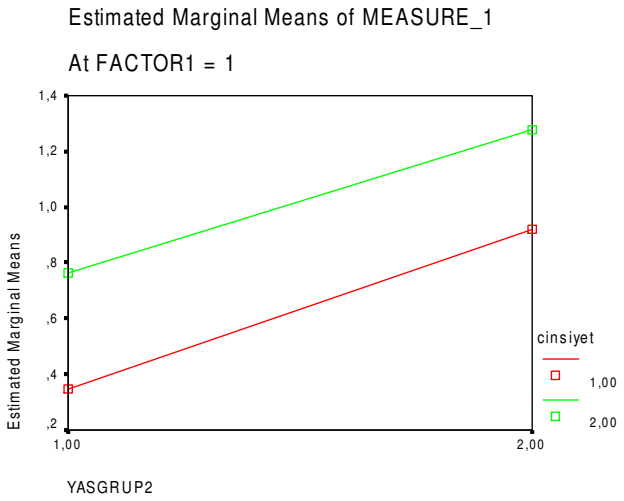

Figure 5.8.The difference in attitude according to age group and gender on S40 seat design

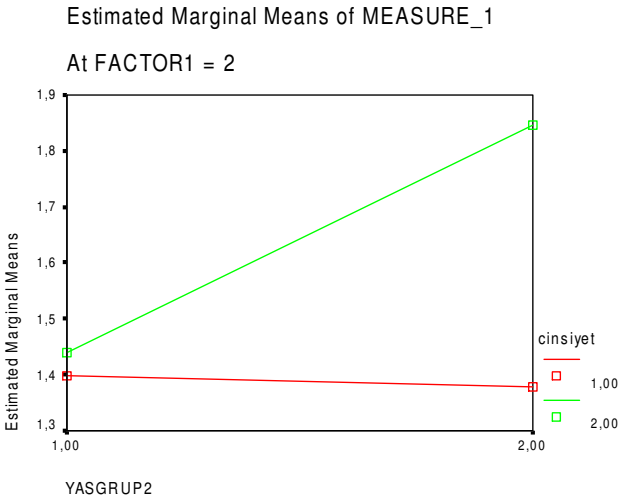

Figure 5.9 The difference in attitude according to age group and gender on S60 seat design

In table 5.7 descriptive statistics in relation to multivariate analysis have been presented.

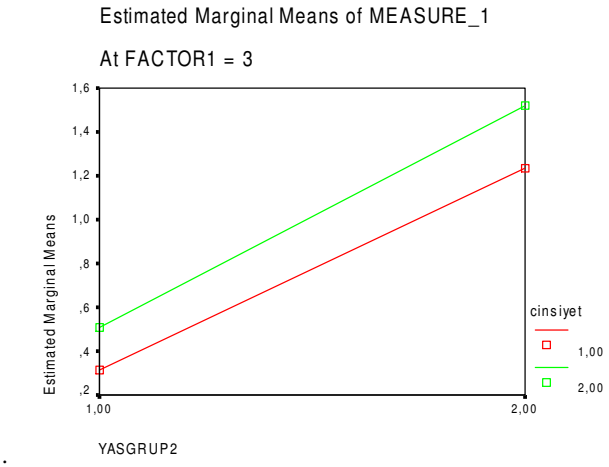

Figure 5.10.The difference in attitude according to age group and gender on S80 seat design

Table 5.7 Descriptive Statistics in relation to multivariate analysis.

	gender	Age group	Mean	Std. Deviation	N
S40 Mean	1,00	1,00	,3469	,5075	7
		2,00	,9184	,9308	7
		Total	,6327	,7789	14
	2,00	1,00	,7653	1,0023	7
		2,00	1,2755	1,0757	7
		Total	1,0204	1,0334	14
	Total	1,00	,5561	,7935	14
		2,00	1,0969	,9840	14
		Total	,8265	,9194	28
S60 Mean	1,00	1,00	1,3980	,4362	7
		2,00	1,3776	,5986	7
		Total	1,3878	,5033	14
	2,00	1,00	1,4388	,8273	7
		2,00	1,8469	,7665	7
		Total	1,6429	,7949	14
	Total	1,00	1,4184	,6357	14
		2,00	1,6122	,7042	14
		Total	1,5153	,6656	28
S80 Mean	1,00	1,00	,3163	1,0134	7
		2,00	1,2347	,7187	7
		Total	,7755	,9693	14
	2,00	1,00	,5102	1,2340	7
		2,00	1,5204	,9456	7
		Total	1,0153	1,1791	14
	Total	1,00	,4133	1,0895	14
		2,00	1,3776	,8204	14
		Total	,8954	1,0661	28

Frequency count : Open Ended Questions Regarding Visual Examination

For the S40, 12 out of 14 female participants designated the waist area of the seat which they examined at first contact. This area has linear horizontal lines depicting the area. For the male participants, 6 out of 14 marked the area. It may be interpreted due to the open ended questions, as those female participants were more sensitive about the lumbar support area which in return may have lead to higher ratings than male participants.

For the S60, 9 out of 14 male participants indicated that prominent side bolsters and the head rest were the first items which they focused on. 7 out of 14 female participants again focused on the waist and back area of the seat backrest where 5 out of 14 have focused first on the prominent side bolsters on the back. The deep sew lines of this seat created an anticipation of embracement on the female participants pronounced distinctly 4 times.

For the S80, 9 out of 14 male participants indicated that they first focused on the seat pan and indicated the reason for this behaviour due to the plainness of the seat pan or the absence of sewing lines or contours. The absence of sewing lines was the main creator of the expectation indicated by the participants that no adequate support would be provided by the seat in lateral accelerations, as there are nearly no side bolster on the seat pan visible.

Comparison of Overall Comfort Ratings in Pre-Seated and Seated Time Domains

In relation to the descriptive statistics regarding the pre-seated and seated overall impression of seat comfort, it is evident that there is significant difference between

Table 5.8 Descriptive Statistics in relation to overall impression of comfort in the Pre-Seated and Seated Time Domains

Statistics		S40 Overall comfort		S60 Overall comfort		S80 Overall comfort	
		Visual	Seated	Visual	Seated	Visual	Seated
		VAR15	VAR16	VAR15	VAR16	VAR15	VAR16
N	Valid	28	28	28	28	28	28
	Missing	0	0	0	0	0	0
Mean		1,1429	,9643	1,7500	2,0357	,8571	1,0000
Median		1,0000	1,0000	2,0000	2,0000	1,0000	1,0000
Mode		2,00	1,00	2,00	2,00	1,00	2,00
Std. Deviation		1,3254	1,2615	,7005	,6929	1,4836	1,4402
Variance		1,7566	1,5913	,4907	,4802	2,2011	2,0741
Minimum		-2,00	-2,00	,00	1,00	-2,00	-1,00
Maximum		3,00	3,00	3,00	3,00	3,00	3,00

the seats, similar to the findings in the multivariate analysis. However the findings display another interesting aspect after being seated in the seats for 15 minutes. For the S40 a small decrease in the overall rating indicates participant's expectations were not met (The Pearson correlation S40, P<0.01 (2-tailed) coefficient between before and after states of comfort impression was 0,668). The seat with the seated environment performed badly and the average scores decreased which were the expected comfort levels. However not only the seat but the comments taken during the test, indicated that the environment was too cramped and the location of the hand brake annoyed most of the participants. For the S80, a small improvement is evident which can be interpreted as the seat performing better than expected. This can be attributed to the fact that the anxiety that the seat will not support laterally has been partially overcome, as commented by a few participants (The Pearson correlation S80, P<0.01 (2-tailed) coefficient between before and after states of comfort

impression was 0,659). And finally for the S60, the much preferred seat performed even better when participants sat for 15 minutes. This can be interpreted as the positive (due to preference) intentions towards the seat were realized when the participants were seated therefore may well have boosted the affective appreciation of the seat leading to the highest scores (The Pearson correlation S60, $P<0.01$ (2-tailed) coefficient between before and after states of comfort impression was 0,706).

Frequency counts: Open Ended Questions: Comments in Seated Position after Inscribed Period

The most significant frequency counts have been reported as follows. For the S40, after being seated for 15 minutes the seat has been depicted as being firmer than expected 5 out of 14 males. For the S60, 6 out of 14 specifically stated that the seat was soft and relaxing where 7 females felt that the seat embraced their body. 3 out of 7 quoted here were "I felt like a part of it". For the S80 not enough side bolsters on the seat pan was the major concern of 8 out of male participants. On top of these certain comments were quite interesting as to provide an insight to the general impression regarding the seat. "Its like a seat that would belong to a father", "An executive office seat", "when I am seated in this seat I felt like the private driver of some one else" underlining negative feelings about being seated in the S80.

Participants' Free Comments:

One of the most general comments concerning all the seats were the disliking of the head rests. Being the most prominent design feature of the seats, focus inevitably did shift to the head rests and after being seated the discovery of the immovability and un adjustability strongly influenced visual decisions of the proceeding seats in the

evaluation. The boldness of the head rest was repeatedly mentioned as a negative aspect by the participants. The knowledge of a movable head rest will provide better effect in the perception of comfort.

5.3 Discussion and Conclusions

In this study, in relation to the findings, important conclusions have been drawn.

First of all the factorial analysis depicted that a general attitude or response was formed by the visual perception of the design of the automobile seat rather than a specific multi- dimensional response. This was mainly related with the aesthetical and symbolic variables. However increasing the sample size of participants and objects may prove different. The correlation coefficients of the SD variables and the overall comfort impression ratings showed that the visual perception of overall impression of automobile seat comfort is in relation with the impression of reliable (güven veren) , impression of comfortable (rahat: comfortable* as in English), beautiful (güzel), elegant (zarif) and attractive (çekici) design in automobile seat design, being the first five variables in descending order. In this respect the first two can be depicted as semantic interpretation variables where the third is aesthetical impression variable and symbolic association variable. As expected, in the automobile environment, comfort is associated with safety and relaxing the user first, with respect to the main function and use value of the seating. However as much as relaxing the seat is expected to look good and have a certain taste in its design. Therefore we can conclude that the visual perception of automobile seat comfort is dependent on these attributes of seat design.

In light of the multivariate and the univariate analysis following the factorial analysis, there was a significant difference in attitudes in response to the three

different designs of the seats. The statistics displayed that the S60's seat was the most preferred, followed by the s80 and the s40, regardless of age and gender. As the study scope was limited to three different designs, not varied design parameters we can briefly conclude that the seat of S60's visual design constituents were the most liked. In relation to the open ended questions and comments by the participants, we can state that the deep contours and sewing lines, with prominent side bolsters on both the seat back and the seat pan created this preferred design. Also in terms of appeal, the plainness of S80's seat pan and seat back, creating a lack of contours lead to a negative impression of lateral support. Therefore we can conclude that in terms of automobile seat design "less is not more", and the need for careful placing of the sew lines creating contours is necessary. Visual clues should be intentionally controlled in the design process performing semantic function of linking product examples to the core meaning the gradation and the fuzzy category boundary.

After being seated in the interior, the mean ratings were compared and again a significant difference between the seats was found, in terms of responses. The S60's seat, which the expected comfort due to visual perception was rated highly positive, performed the best in the seated and physiologically felt comfort. Overlooking the factors of indirect inputs such as the whole interior design and dimensions, we can conclude that if the automobile seat creates a positive impression, this leads to even more positive physical experience when the expectancies are met. This supports the statement of Norman (2004) and Helander (2003) where they have underlined as long as ergonomics guidelines have not been violated, aesthetics design will perform better if the design adequately represents what is to be expected and more. Therefore as Griffin (2001) has indicated, the importance of the refinement of the design by locating the key semantic clues (elements) in the areas where users in interaction

naturally look, “making things visible” and comprehensible has been underlined by this studies findings. The associations with the product at different degrees in accordance with individuals’ social and ideological identity disposition has proven to be a major factor in the perception of the products message. However on top of all, the ability of the seat to perform in concordance with the expectancies is the vital element in the perception of the total comfort.

CHAPTER 6

CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDIES

In this study the main problem has been stated to be establishment of visual criteria regarding the seat design, concerning the discipline of design, which will enhance the perception of comfort of automobile seats by the individuals using them. The main problem had been formulated in sub problems. Review of the sub-problems and the derived conclusions in response to these problems forms the conclusion.

- What are comfort definitions utilized by current literature and dimensions of comfort in relation to automobile seat design? What are the models proposed for comfort/discomfort interaction?
- What are the current approaches utilised in assessing the perception of "comfort"/ "discomfort" in automobile seat evaluation? (The methods in assessment and identification of the factors contributing to the perception of comfort).

In relation to the literature survey conducted, “comfort” was defined as an object and time related state of a human being. due to the reason that object affords a certain number of descriptors in relation to the occupied space, time and function in a human beings life. Comfort was proposed as an organization(entity) of descriptors and an entity of feelings in the human mind. Discomfort was also depicted as an entity of factors acting on the human organism. The two feelings of comfort and discomfort were described as three dimensional planes, topologies of feeling (semantic space topology). They may super positioned or intersecting in relation to the object

function and time due to the factors at play. The most important finding was that the topology is formed by the weight of the organisational factors. In relation to the conceptualisation of comfort and discomfort in this space geometry sense, the time domain of the perceptions gained importance.

In coherence with the study, two interdependent, time sequenced, cyclic, co-existing operational definition for automobile seat comfort and a model has been proposed.

- **Pre-seated visually perceived seat comfort**; an intuition due to the visual inspection that the seat will offer a pleasant state of physiological, psychological and physical harmony for the human being and the environment.
- **Seated comfort**; "absence of discomfort" that does not entail a positive effect regarding emotional or mental state. This definition should be coincident with the occupant's empirical perception of being at ease (Reynolds,1993), and should be able address the complete physically functional needs of the occupant, circulation, pressure distribution, biomechanics, strain, fatigue retardation and habitability (in relation to geometry imposed by the car) with other physiological and anthropometrical issues. Homeostasis of the human body the sympathetic and para- sympathetic nervous systems are vital for this definition. However if the above conditions are supplied, the satisfactory compliance of the conditions with the previous intuition leads to positive affect.

➢ What are the current ergonomic criteria for promotion of comfort in / physical terms available in literature regarding automobile seat design?

In relation to the sub problem in chapter three, functional seat attributes which form ergonomics criterions have been investigated. Ergonomics guidelines for seat design and attributes providing the **"working"** physiology with homeostasis and the necessities of humans geometry and morphology in order to continue functioning avoiding discomfort were depicted and physical/engineering attributes were tabulated. However as a result of the survey it was found that although being a major attribute in comfort studies there were no design guidelines on the overall appearance (Physical shape of the seat). The need for translation of psychological (cognitive and affective) variables into customer requirements which in return will be transformed into visual design parameters were acknowledged.

- What are the psychological constituents of comfort regarding automobile seat design and the layers of design for semantic and emotional function?
- What are the possible visual constituents (factors) in comfort perception and semantic interpretation?
- What are the basic mechanisms of aesthetics that affect this mechanism of visual perception?

In the fourth chapter, three levels of product design in relation to the three levels of processing have been depicted in visual domain. These three components included both emotions and cognition In order to creation visual perception of comfort these three levels of processing has to be satisfied. It was concluded the first level of design being aesthetic impression; a balance of stimuli and a zone between novelty and typicality was needed. For the second level, the necessity of locating key semantic clues (elements) in the areas, where users in interaction naturally look to on

encountering, making the function visible and comprehensible was indicated. In the third level, the symbolic associations at different degrees were found to amplify or dampen the perception of the products comfort message in accordance with individuals' social and ideological identity disposition; creating ones own perceived being, role and mission, Therefore it was concluded that successful design had to excel at all levels forming an entity of factors where the design requirements for each level differ.

- How can the perception of "comfort" in automobile seat design be enhanced by aesthetics or visual domain design?

In the fifth chapter, in order to find which factors of perceptions in the visual domain affect the perception of comfort a study was carried out. The factorial analysis indicated that there was a general attitude or response by the visual perception of the design of the automobile seat rather than a specific multi- dimensional response. This was mainly related with the aesthetical and symbolic variables. The correlation coefficients of the SD variables and the overall comfort impression ratings showed that the visual perception of overall impression of automobile seat comfort is in relation with the impression of safeness (güven veren) , impression of relaxing (rahat: comfortable as in English), beautiful (güzel), elegant (zarif) and attractive (çekici) design in automobile seat design, being the first five variables in descending order. In this respect the first two were depicted as semantic interpretation variables where the third is aesthetical impression variable and symbolic association variable. As expected, in the automobile environment, comfort was associated with safety and relaxing the user first, with respect to the main function and use value of the seating.

However as much as relaxing the seat is expected to look good and have a certain taste in its design. Therefore we can concluded that the visual perception of automobile seat comfort is dependent on these attributes of seat design.

We found that regardless of age and gender there was a conformity of preference among the participants Deep contours and sewing lines, with prominent side bolsters on both the seat back and the seat pan created this preferred design. Also in terms of appeal, the plainness of seat pan and seat back, creating a lack of contours lead to a negative impression of lateral support. Therefore we concluded that in terms of automobile seat design “less is not more”, and the need for careful placing of the sew lines creating contours is necessary.

Another major important conclusion was that overlooking the factors of indirect inputs such as the whole interior design and dimensions, if the automobile seat creates a positive impression, it lead to even more positive physical experience when the expectancies were met. This supported the statement of Norman (2004) and Helander (2003) where they have underlined as long as ergonomics guidelines have not been violated and if the design adequately represents what is to be expected the aesthetic design will perform better. Therefore we can conclude that, the ability of the seat to perform in concordance with the original expectancies is the vital element in the perception of the total comfort.

Actually objects isolated in the real world exist in the overlapped and tangled links, which form their identity in the conceptual world of the human mind. In its own sense comfort is a learned mental concept. It is influenced by the object and activities of the real world, experience and so forth with the automobile. The sensation of visual comfort has been attributed to the shape, form and colour and "perceived

space" of the vehicle interiors by professionals and researchers alike, which encompasses a harmonious and ambient feeling (Buti, 2001). In terms of the seat, the styling will act as the basis for an interpretation whether reinforcing or decaying an impression of comfort and the forming qualities of comfort. The existence of a coherent unity of characteristics, “comfort” has to apply across different functions and qualities of the seat. It is important that a product’s appearance is congruent with other sensory aspects of design as “the product form that the eye sees creates in the observer, expectation of what the other senses will perceive” (Nathan et al.2004).

As stated earlier, upon confrontation with the product, a complex entity for most, people tend to develop and rely on, an overall feeling about the product forming a certain attitude about the product, an intuition just like encountering first time another. The messages are being sent through products via stimulus in colour, shape, form, and texture in, whether intuitively or intentionally. In order to create a successful design of automobile comfort, the designer should strike a balance in creating the intended profile, purposefully use cues for the intended message. The dangers of relying solely on intuition and anecdotal evidence have been well acknowledged in justify a product’s visual appearance. If an overall message is to be conveyed, the completeness, coherence of characteristics and attributes are of prime importance. In relation to these objectives, the development of visual features should aim at a holistic profile of intended feeling, intuition and identity for the user. The relation between function and surface appearance, performance and formal properties, should be defined as clearly as possible, in order to provide a guided visual interaction. As Norman (2004) has summarized objects, like humans gain trust from experience it, develops over time, where the consistency of same precise performance will build it up.

The conscious explorations of the semantic space can help the designer to anticipate the nature of feelings and develop strategies to supply the intended feeling in the design.The refinement of the design by locating the key semantic clues (elements) in the areas where users in interaction naturally look, “making things visible” and comprehensible. On top of these, in the third level, the associations with the product at different degrees in accordance with individuals’ social and ideological identity disposition; creating ones own perceived being, role and mission, will amplify or dampen the perception of the products message (profile). The successful design has to supply at all levels where the design requirements for each level afford different factors.

Major manufacturers have built their own “reference databases” for sensorial analysis and created “preference maps” due to investigation of the preferences of the users, the same can be applied to the visual design of automobiles seats. Data bases that contain and combine preferences with design parameters will enable designers to create semantically correct, yet innovative seats. The correlation of impressions with design parameters will create for proper guidelines in design.

Suggestions For Future Studies

A basic pattern to follow in creation of visual perception of comfort on any product should be as follows

- Decide the objective product to be designed
- Collect the existing products in the market
- Select the adequate antonym pairs or words using questionnaires,
- Divide the seat into several elements (parts) based on their functions forming basic categories so as to modify them during the procedure

- Identify the attributes that users prefer with semantic differential method for each element and factor the multi-dimensional definition of comfort

Particularly the capturing of a consistent pattern of profile (semantic or otherwise) regarding the factors of gender, age, or personality would be important in gaining decisive form attributes of comfort feeling.

The need for a research solely concentrated on the concept (definition) of comfort is evident as the concept is new for the Turkish language and literature. The boundaries of the semantic space should be analysed and a study similar to that of Osgood (1957) suggested should be carried out. A larger sample of participants and antonym pairs for semantic differential could provide a clearer picture of the main dimensions (factors) of the definition of comfort. Up on completion of such a study, the main effects of gender and age and other factors of interest (such as education, income …..etc.) and the interaction for these effects can be investigated.

Following such a study, specifically automobile seat comfort research can progress on to find the attributes or design parameters with correlation to the dimensions of comfort understanding in the Turkish population. The SD to be carried out can be done by either on actual seats or photographs of the actual seats SD methods and simulated environments. In this relation a database for designers can be formed which would display characteristics and attributes according to the comfort characteristic proposed or needed.

Another major aspect of further field studies should include the use of eye-tracker device in order to capture the specific point, where the subjects look subconsciously. Thereby instead of asking participants to evaluate consciously the probable areas of reference features, subconscious data and an insight to inner workings of the mind.

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APPENDIX A

KONFOR

ITICI	□ □ □ □ □ □ □	ÇEKICI
GUVEN VERMEYEN	□ □ □ □ □ □ □	GUVEN VERICI
TEK DUZE	□ □ □ □ □ □ □	CANLI
BASIT	□ □ □ □ □ □ □	SOFISTIKE
SERT	□ □ □ □ □ □ □	YUMUŞAK
RAHATSIZ	□ □ □ □ □ □ □	RAHAT
ÇIRKIN	□ □ □ □ □ □ □	GUZEL
SIKICI	□ □ □ □ □ □ □	ILGINÇ
UCUZ	□ □ □ □ □ □ □	LUKS
DAR	□ □ □ □ □ □ □	GENIŞ
KOŞELI	□ □ □ □ □ □ □	YUVARLAK
VUCUDU KAVRAMAYAN	□ □ □ □ □ □ □	VUCUDU KAVRAYAN
SOGUK	□ □ □ □ □ □ □	SICAK
KABA	□ □ □ □ □ □ □	ZARIF

GENEL OLARAK

KONFORSUZ	□ □ □ □ □ □ □	KONFORLU

S40 S60 S80

S40

GENEL OLARAK

KONFORSUZ	☐ ☐ ☐ ☐ ☐ ☐ ☐	KONFORLU

Soru 1: Oturmadan önce görebildigin kadarıyla ilk olarak dikkat ettigin veya senin dikkatini çeken koltugun hangi bölgesiydi?

Soru 2: Oturduktan sonra 15 dakika içinde seni beklentin dışında rahatsız eden/ rahat ettiren bir bölge gösterebilrimisin?

Notlar:

S60

GENEL OLARAK

KONFORSUZ	☐ ☐ ☐ ☐ ☐ ☐ ☐	**KONFORLU**

Soru 1: Oturmadan önce görebildigin kadarıyla ilk olarak dikkat ettigin veya senin dikkatini çeken koltugun hangi bölgesiydi?

Soru 2: Oturduktan sonra 15 dakika içinde seni beklentin dışında rahatsız eden/ rahat ettiren bir bölge gösterebilrimisin?

Notlar:

S80

GENEL OLARAK

KONFORSUZ	☐ ☐ ☐ ☐ ☐ ☐ ☐	KONFORLU

Soru 1: Oturmadan önce görebildigin kadarıyla ilk olarak dikkat ettigin veya senin dikkatini çeken koltugun hangi bölgesiydi?

Soru 2: Oturduktan sonra 15 dakika içinde seni beklentin dışında rahatsız eden/ rahat ettiren bir bölge gösterebilrimisin?

Notlar:

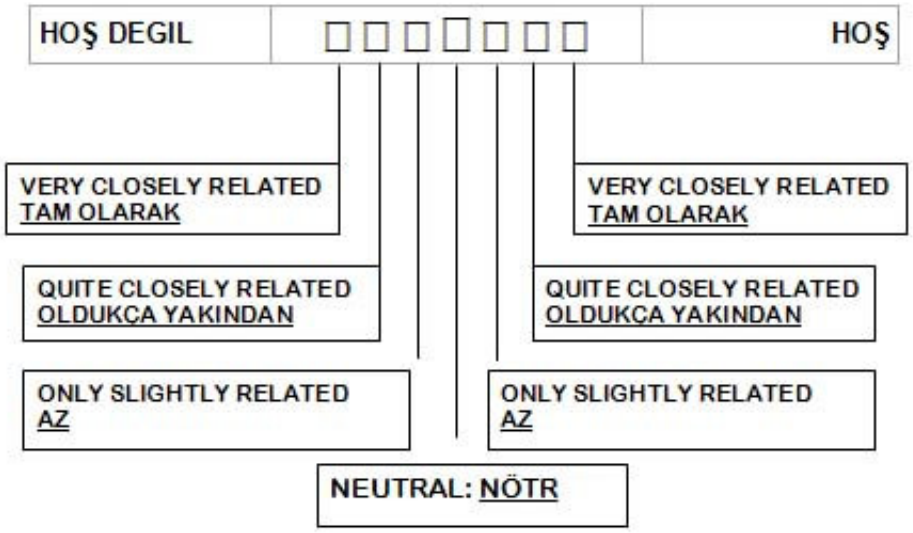
KAVRAM / CONCEPT

IF YOU FEEL THE CONCEPT IS **VERY CLOSELY RELATED** , **QUITE CLOSELY RELATED, ONLY SLIGHTLY RELATED** WITH ONE END OR THE OTHER END OF THE SCALE YOU SHOULD MARK THE RELEVANT BOX.

IF YOU FEEL THE CONCEPT IS **IRRELEVANT** OR **EQUALLY ASSOCIATED** WITH EITHER END OF THE SCALE THEN YOU SHOULD MARK **NEUTRAL BOX\ THE MIDDLE.**

EXAMPLE/ ÖRNEK

DIŞ MUAYENESI



APPENDIX B

Factor Analysis

Total Variance Explained

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	7,158	51,128	51,128	7,158	51,128	51,128	5,908	42,199	42,199
2	1,431	10,220	61,347	1,431	10,220	61,347	1,918	13,699	55,898
3	1,020	7,285	68,632	1,020	7,285	68,632	1,783	12,734	68,632
4	,802	5,730	74,362						
5	,677	4,835	79,196						
6	,638	4,559	83,755						
7	,530	3,789	87,544						
8	,406	2,898	90,442						
9	,362	2,587	93,029						
10	,306	2,184	95,212						
11	,229	1,636	96,849						
12	,184	1,315	98,164						
13	,151	1,078	99,242						
14	,106	,758	100,000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
VAR00001	,851	-2,14E-02	-9,20E-02
VAR00002	,811	,156	-,126
VAR00003	,842	-,274	-,169
VAR00004	,806	-5,95E-02	-,276
VAR00005	,402	,479	,428
VAR00006	,776	,150	7,276E-02
VAR00007	,863	-,101	-2,32E-02
VAR00008	,800	-,313	-,134
VAR00009	,698	,255	-,374
VAR00010	,326	,699	-,314
VAR00011	,419	,524	,330
VAR00012	,622	-7,22E-02	,389
VAR00013	,739	-,206	,388
VAR00014	,754	-,303	,186

Extraction Method: Principal Component Analysis.
a. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
VAR00001	,769	,220	,305
VAR00002	,655	,280	,437
VAR00003	,883	1,713E-02	,180
VAR00004	,760	4,579E-02	,387
VAR00005	,104	,732	,169
VAR00006	,612	,413	,291
VAR00007	,812	,231	,209
VAR00008	,861	6,562E-03	,117
VAR00009	,526	,111	,635
VAR00010	-1,18E-02	,274	,786
VAR00011	,105	,690	,269
VAR00012	,555	,470	-,117
VAR00013	,721	,436	-,172
VAR00014	,793	,235	-,101

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 11 iterations.

Component Transformation Matrix

Component	1	2	3
1	,884	,354	,305
2	-,461	,562	,686
3	-,071	,747	-,660

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
VAR00001	1,1905	1,3215	84
VAR00002	1,5833	1,1108	84
VAR00003	,7262	1,5473	84
VAR00004	,8929	1,4891	84
VAR00005	1,1190	1,2650	84
VAR00006	1,5357	1,1559	84
VAR00007	1,0714	1,3152	84
VAR00008	,2976	1,3602	84
VAR00009	1,4286	1,2152	84
VAR00010	1,6667	1,6815	84
VAR00011	1,2024	1,3513	84
VAR00012	1,1786	1,4409	84
VAR00013	,5119	1,3308	84
VAR00014	,7024	1,4544	84
VAR00015	1,2500	1,2599	84

Correlations

		VAR00001	VAR00002	VAR00003	VAR00004	VAR00005	VAR00006	VAR00007	VAR00008	VAR00009	VAR00010	VAR00011	VAR00012	VAR00013	VAR00014	VAR00015	VAR00016
VAR00001	Pearson Correlation	1,000	,596**	,733**	,678**	,318**	,697**	,748**	,632**	,609**	,230*	,329**	,406**	,560**	,619**	,651**	,546**
	Sig. (2-tailed)	.	,000	,000	,000	,003	,000	,000	,000	,000	,036	,002	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00002	Pearson Correlation	,596**	1,000	,627**	,599**	,259*	,692**	,623**	,625**	,625**	,389**	,354**	,499**	,554**	,489**	,764**	,623**
	Sig. (2-tailed)	,000	.	,000	,000	,018	,000	,000	,000	,000	,000	,001	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00003	Pearson Correlation	,733**	,627**	1,000	,792**	,177	,548**	,768**	,749**	,492**	,131	,211	,503**	,537**	,622**	,579**	,460**
	Sig. (2-tailed)	,000	,000	.	,000	,107	,000	,000	,000	,000	,234	,054	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00004	Pearson Correlation	,678**	,599**	,792**	1,000	,269*	,566**	,650**	,652**	,585**	,269*	,238*	,402**	,454**	,564**	,573**	,461**
	Sig. (2-tailed)	,000	,000	,000	.	,013	,000	,000	,000	,000	,013	,029	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00005	Pearson Correlation	,318**	,259*	,177	,269*	1,000	,450**	,270*	,175	,249*	,268*	,268*	,253*	,336**	,170	,276*	,337**
	Sig. (2-tailed)	,003	,018	,107	,013	.	,000	,013	,111	,023	,014	,014	,020	,002	,122	,011	,002
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00006	Pearson Correlation	,697**	,692**	,548**	,566**	,450**	1,000	,616**	,533**	,555**	,155	,377**	,390**	,462**	,512**	,701**	,544**
	Sig. (2-tailed)	,000	,000	,000	,000	,000	.	,000	,000	,000	,159	,000	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00007	Pearson Correlation	,748**	,623**	,768**	,650**	,270*	,616**	1,000	,675**	,554**	,251*	,304**	,559**	,598**	,654**	,680**	,558**
	Sig. (2-tailed)	,000	,000	,000	,000	,013	,000	.	,000	,000	,021	,005	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00008	Pearson Correlation	,632**	,625**	,749**	,652**	,175	,533**	,675**	1,000	,498**	,128	,137	,384**	,654**	,648**	,645**	,607**
	Sig. (2-tailed)	,000	,000	,000	,000	,111	,000	,000	.	,000	,245	,213	,000	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00009	Pearson Correlation	,609**	,625**	,492**	,585**	,249*	,555**	,554**	,498**	1,000	,389**	,262*	,348**	,362**	,346**	,527**	,478**
	Sig. (2-tailed)	,000	,000	,000	,000	,023	,000	,000	,000	.	,000	,016	,001	,001	,001	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00010	Pearson Correlation	,230*	,389**	,131	,269*	,268*	,155	,251*	,128	,389**	1,000	,327**	,094	,099	,107	,199	,246*
	Sig. (2-tailed)	,036	,000	,234	,013	,014	,159	,021	,245	,000	.	,002	,393	,372	,334	,069	,024
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00011	Pearson Correlation	,329**	,354**	,211	,238*	,268*	,377**	,304**	,137	,262*	,327**	1,000	,291**	,270*	,264*	,295**	,129
	Sig. (2-tailed)	,002	,001	,054	,029	,014	,000	,005	,213	,016	,002	.	,007	,013	,015	,006	,241
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00012	Pearson Correlation	,406**	,499**	,503**	,402**	,253*	,390**	,559**	,384**	,348**	,094	,291**	1,000	,549**	,445**	,506**	,384**
	Sig. (2-tailed)	,000	,000	,000	,000	,020	,000	,000	,000	,001	,393	,007	.	,000	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00013	Pearson Correlation	,560**	,554**	,537**	,454**	,336**	,462**	,598**	,654**	,362**	,099	,270*	,549**	1,000	,715**	,684**	,656**
	Sig. (2-tailed)	,000	,000	,000	,000	,002	,000	,000	,000	,001	,372	,013	,000	.	,000	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00014	Pearson Correlation	,619**	,489**	,622**	,564**	,170	,512**	,654**	,648**	,346**	,107	,264*	,445**	,715**	1,000	,666**	,546**
	Sig. (2-tailed)	,000	,000	,000	,000	,122	,000	,000	,000	,001	,334	,015	,000	,000	.	,000	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00015	Pearson Correlation	,651**	,764**	,579**	,573**	,276*	,701**	,680**	,645**	,527**	,199	,295**	,506**	,684**	,666**	1,000	,696**
	Sig. (2-tailed)	,000	,000	,000	,000	,011	,000	,000	,000	,000	,069	,006	,000	,000	,000	.	,000
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
VAR00016	Pearson Correlation	,546**	,623**	,460**	,461**	,337**	,544**	,558**	,607**	,478**	,246*	,129	,384**	,656**	,546**	,696**	1,000
	Sig. (2-tailed)	,000	,000	,000	,000	,002	,000	,000	,000	,000	,024	,241	,000	,000	,000	,000	.
	N	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).