

Determining Perceptual Characteristics of Automotive Interior Materials

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ABSTRACT

This paper presents results of a three-phase research project aimed at understanding how future automotive interior materials should be selected or designed to satisfy the needs of the customers. The first project phase involved development of 22 five-point semantic differential scales to measure visual, visual-tactile, and evaluative characteristics of the materials. Some examples of the adjective pairs used to create the semantic differential scales to measure the perceptual characteristics of the material are: a) Visual: Light vs. Dark, Flat vs. Shiny, etc., b) Visual-Tactile: Smooth vs. Rough, Slippery vs. Sticky, Compressive vs. Non-Compressive, Textured vs. Non-Textured, etc., c) Evaluative (overall perception): Dislike vs. Like, Fake vs. Genuine, Cheap vs. Expensive, etc. In the second phase, 12 younger and 12 older drivers were asked to evaluate a number of different automotive interior materials by using the 22 semantic differential scales. The subjects were also asked to provide: a) preference ratings on each of the material characteristic scales to indicate their "ideal preferred levels" (i.e. what level of each material characteristic they would ideally prefer for armrests and seats), and b) importance ratings to each of the material characteristics scales. In the third phase, the obtained perceptual ratings data were statistically analyzed to obtain: a) effects of subject age and gender on various perceptual ratings for different types of materials, and b) regression models to predict evaluative ratings (e.g. Dislike vs. Like) as functions of other perceptual material characteristics.

INTRODUCTION

The goal of this project was to understand how future materials should be selected or designed to satisfy the needs of the users with specific attention to the elderly [1, 2, 3, and 4]. At present, systematic studies on measurement of both the physical and perceived characteristics are lacking. Such data are needed to design various products that interface the users through the sense of vision and tactile feel during their usage through grasping/holding, walking, wrapping, covering, partitioning, etc.

Many studies reported in the literature have shown varied levels of successes in measuring physical characteristics of materials that relate to subjective perception of different characteristics [5 to 8]. Several past studies on the use of semantic differential scaling showed that subjects can discriminate and scale different visual and tactile characteristics of materials with fairly good level of agreement [9, 10]. Such scaling data can be used to select interior materials in different parts of automotive interiors based on minimization of costs and increasing customer perceived values [11].

OBJECTIVES

The specific objectives of the project were to: 1) collect different samples of materials used in interiors of automotive products, 2) develop and apply a method to measure their perceived characteristics by the use of visual and tactile senses, 3) analyze the data to obtain relationships between different response variables and material characteristics, 4) determine important material characteristics related to their preference, comfort and pleasing perceptions.

METHOD

Two studies, one using armrest materials and the other using seat materials were conducted by using the same evaluation procedure. In each study 24 subjects, 50:50 males-to-females and 50:50 younger (below 25 years age) and older (over 50 years age), participated in the studies. Each study took about one hour to complete. Before the experimental part, the subjects were told about the overall goal of the project and asked to complete a consent and demographic information form. Their near visual acuity and 2-point tactile discrimination threshold were measured.

For the armrest study, the subject was seated in a vehicle buck shown in Figure 1. The armrest samples obtained from late model production vehicles were mounted on the driver's door at the driver's preferred height and each subject was asked to evaluate six armrest samples in a random order. All the armrests were draped in a black cloth and the test material was exposed through a small rectangular opening (about 40 mm x 100 mm) in the black cloth on horizontal arm resting portion of each armrest to avoid the effect of other variables such as shape, stitches, edges, etc.



Figure 1. Armrest Evaluation Set-up

For the seat materials evaluation study, each subject sat in the same vehicle buck and was asked to evaluate seat materials presented on the passenger side seat cushion through a rectangular opening in the black masking cloth as shown in Figure 2.

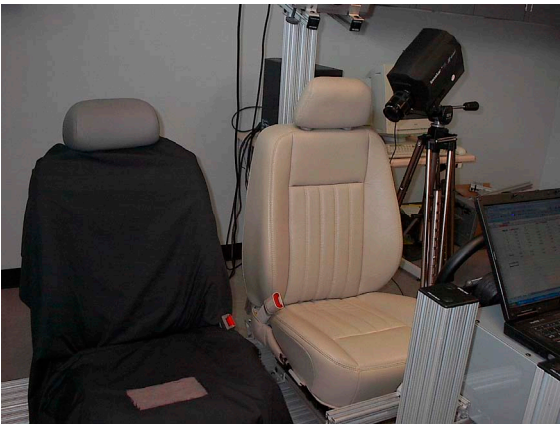


Figure 2. Seat Evaluation Set-up

Figures 3 and 4 present pictures of test samples used for the armrest and seat materials evaluation respectively.

Each subject was asked to evaluate each material sample by providing ratings on 22 five-point semantic differential scales. The semantic differential scales use a pair of opposite adjectives that define each end of the scale. For example, Figure 5 presents a semantic differential scale for "Smooth vs. Rough".

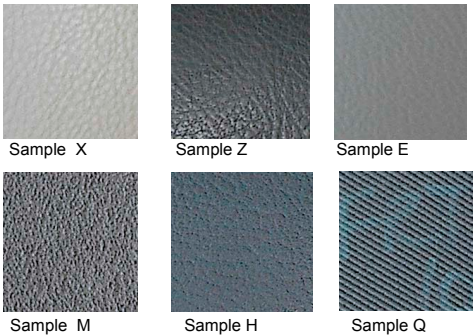


Figure 3. Six Armrest Materials Used for Evaluation

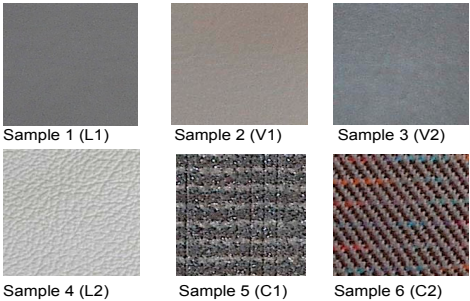


Figure 4. Six Seat Materials Used for Evaluation

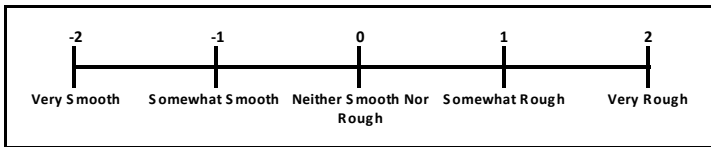


Figure 5. Illustration of a 5-Point Semantic Differential Scale of Material Characteristic Defined by “Smooth vs. Rough” Adjective Pair

The 22 adjective pairs used for evaluation were divided into three groups: a) Visual – The characteristics that involved use of vision only (subjects were not allowed to touch and feel the materials), b) Visual-Tactile – The subjects were asked to evaluate these characteristics using both vision and touch feel, C) Evaluative – The subjects were asked to make overall judgment on the material by considering all visual and tactile characteristics.

The 22 adjective pairs used to define 5-point semantic differential scales were as follows:

- a) Visual – 1) Light vs. Dark, 2) Shiny vs. Flat, 3) Colorful vs. Neutral, 4) Ordered vs. Random, 5) Non-metallic vs. Metallic, 6) Woven vs. Non-Woven, 7) Unpainted vs. Painted, 8) Plain vs. Textured, and 9) Bright vs. Dull.
- b) Visual and Tactile – 10) Smooth vs. Rough, 11) Slippery vs. Sticky, 12) Compressive vs. Non-Compressive, 13) Textured vs. Non-Textured, 14) Warm vs. Cold, 15) Solid vs. Flimsy, 16) Oily vs. Dry, and 17) Soft vs. Harsh.
- c) Evaluative – 18) Dislike vs. Like, 19) Comfortable vs. Uncomfortable, 20) Pleasing vs. Non-Pleasing, 21) Fake vs. Genuine, and 22) Expensive vs. Cheap.

At the end of each session, the subjects were asked to provide: a) 5-point ratings indicating ideal level of each of the visual and visual-tactile characteristics (using only the first 17 scales), and b) importance rating using a 10-point scale (where, 10 = most important and 0 = least important) for each of the 17 scales.

RESULTS

Figures 6, 7 and 8 provide means and 95% confidence intervals of the ratings of 24 subjects for the visual, visual-tactile and evaluative scales, respectively for the armrest materials. In these Figures, the y-axis presents the 5-point semantic differential scale ranging from -2 to +2 units.

The adjective pairs are presented on the x-axis. The first adjective in each pair represents the negative side of the scale and the second adjective represents the positive

side of the scale. Thus, for the first adjective pair of “Light-Dark” (Figure 6) is presented as: -2 = Very Light, -1 = Somewhat Light, 0 = Neither Light or Dark, +1 = Somewhat Dark, and +2 = Very Dark.

Similarly, Figures 9, 10, and 11 provide interval plots on the ratings of 16 subjects for the visual, visual-tactile and evaluative scales, respectively for the seat materials.

The interval plots in Figures 6 to 11 allow visual comparison between different materials and thus illustrate differences in materials and profiles of perceived characteristics of the materials.

The analysis of variance (ANOVA) tests were conducted on each response variable (defined by each of the 22 rating scales) to determine if the subject age, subject gender, and materials (different samples) had a significant effect at the significance probability of 0.05. The results of the ANOVA tests are provided in Table 1.

The data presented in Table 1 show the following:

- 1) The effect of age was not observed on most of the response variables.

Only 2 (“Soft vs. Harsh” and “Fake vs. Genuine”) out of the 22 response variables showed significant (at $p \leq 0.05$) effects of age for the armrest samples. In addition, the ratings for “Smooth vs. Rough” and “Dislike vs. Like” were affected by age at 0.08 significance probability for the armrest materials.

Similarly, for the seat materials, only 4 out of 21 response variables were significantly (at $p \leq 0.05$) affected by subject age.

- 2) The effect of subject gender was not observed on most response variables.

Only 3 out of 22 response variables for armrest and 3 out of 21 response variables for seats were significantly affected (at $p \leq 0.05$) by subject’s gender.

- 3) In general, the materials (samples) for both the armrest and seats had substantial influence on the response variables.

15 out of 22 armrest response variables and 16 out of 21 seat response variables had significant effect (at $p \leq 0.05$) of materials.

Ideally Preferred Material Characteristics-

After the evaluation six material samples in each study, the subjects were asked to provide ratings to indicate their ideally preferred levels of material characteristics. The first 17 of the 22 semantic differential scales

defining the visual and visual-tactile characteristics were used for the ideally preferred ratings.

Figures 12 and 13 provide means and 95% confidence intervals indicating ideally preferred levels of characteristics of the armrest and seat materials respectively.

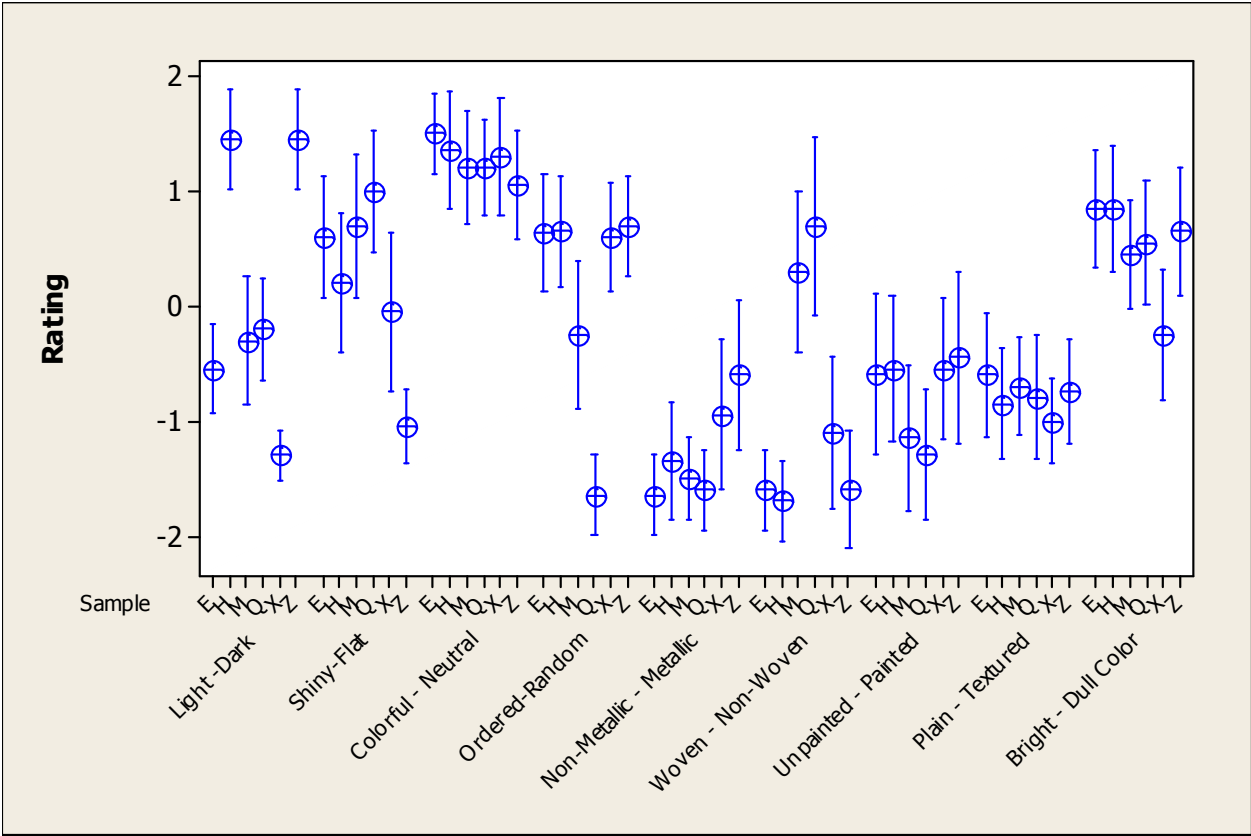


Figure 6. Interval Plot of Armrest Materials Ratings for Visual Scales