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Product appraisal dimensions impact emotional responses and visual acceptability of instrument panels

Nathalie Herbeth [a,b,*], David Blumenthal [c,d,e,1]

[a] Centre de Recherche en Gestion, Ecole Polytechnique, Paris, France
[b] Renault SAS, Guyancourt, France
[c] AgroParisTech, UMR1145 Ingénierie Procédés Aliments, F-91300 Massy, France
[d] INRA, UMR1145 Ingénierie Procédés Aliments, F-91300 Massy, France
[e] CNAM, UMR1145 Ingénierie Procédés Aliments, F-75002 Paris, France

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ABSTRACT

The way designers deal with emotions could be an important source of differentiation in highly competitive markets like the car industry. Indeed, technological improvements and safety constraints have leveled off the perceived differences between cars.

Recently, several studies have shown strong correlations between overall product satisfaction and product-elicited emotions. Other studies have documented relationships between evaluative criteria supporting product evaluation, satisfaction and emotions. How to integrate emotions when designing a car is still a broad field of investigation and raises various questions. For instance, in the early phases of product development, prototypes are often non-functional, so assessors cannot use them. Therefore, satisfaction as a global product judgment cannot be evaluated. Moreover, a car is composed of multiple elements corresponding to the division of the design process whereas the consumer's emotional responses come from a global car appraisal.

The purpose of our study is to test the relationships between product attributes, emotions and visual acceptability in focusing on a subpart of the car. The responses of a hundred consumers to eighteen instrument panel pictures were analyzed. Affective data were collected using the two first dimensions pleasure and arousal of the PAD scale. Product appraisal was measured using thirteen bipolar scales developed during preliminary tests with eight assessors.

It was found that consumers were able to differentiate between instrument panel pictures based on visual acceptability, emotions and appraisal dimensions. Hierarchical Cluster Analysis performed on the liking scores yielded three subgroups of consumers. Pleasure was strongly correlated with visual acceptability for the population and for each cluster of consumers. The correlations between the arousal and the appraisal dimensions highlighted that arousal may have different meanings for the clusters of consumers. Moreover, the arousal seemed to have a negative meaning on average for the French consumers we interviewed.

Contents

* Corresponding author. Address: Technocentre Renault, TCR AVA 1 65, 1 avenue du Golf, 78288 Guyancourt, Cedex, France. Tel.: +33 1 76 85 99 30; fax: +33 1 76 86 90 70.
E-mail addresses: nathalie.herbeth@renault.com (N. Herbeth), david.blumenthal@agroparistech.fr (D. Blumenthal).
[1] Address: 1 avenue des Olympiades, 91744 Massy, France. Tel.: +33 1 69 93 51 93.

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1. Introduction

Recent research in marketing has confirmed the impact of emotions on consumer's satisfaction (Ladhari, 2006; Machleit & Mantel, 2001; Mano & Oliver, 1993; Westbrook, 1987; Wirtz & Bateson, 1999), behavior (Andrews, Drennan, & Bennett, 2005; Karapanos, Zimmerman, Forlizzi, & Martens, 2009; Ladhari, 2007) and on the purchase decision (Seva, Duh, & Helander, 2007; Tsai, 2005). There is also an increasing interest for emotions among the sensory analysis community, studying the relationships between emotions and food (King & Meiselman, 2010), perfume (Porcherot et al., 2010) or automotive products (Wellings, Williams, & Pitts, 2008).

1.1. Emotions and the automotive new product development constraints

Today's business environment is dynamic, characterized by changing markets, high rates of technical obsolescence, shorter product life cycles and increasing global competition (Carbon & Leder, 2007; Envick & Wall-Mullen, 2009). Firms try to optimize their new products or services process development, taking into account the customer's needs, satisfaction, and more recently emotions (Jordan, 1998; Veryzer & Borja de Mozota, 2005).

The automobile is a complex and emotional product. Oliver and Westbrook (1993) distinguished five alternative automobile contexts in which emotions may be elicited: the purchase process, the vehicle itself, the ownership of the vehicle, driving or using the vehicle, caring for or maintaining the vehicle. Focusing on the vehicle itself, cars traditionally give rise to freedom (they allow you to go where you want when you want), pride when driving a premium car, anger when being cut up by someone on the road, excitement or fear when driving too fast. Brands, advertising or even road safety make use of these facts. These strong emotions are linked to the car seen as a whole or in a driving context.

Clark and Fujimoto (1991) underlined that a car is composed of many elements (seats, dashboard, instrument panel) which are developed separately at the same time by different teams and put together quite late in the design process. The early stages focus on what the product must be in terms of specifications to meet the customer target and price defined by the product planning or upstream department. Then the designers, the engineers and the suppliers will try to develop the car corresponding to these initial specifications. No prototypes apart from sketches or digital representations are available in early stages of product development. Prototypes that conform to the specifications and that can be tested by potential future consumers are available late in the design process. Whatever the results of the consumer study, it is too late to propose radical changes to the vehicle project: only some minor changes can still be conducted on the new product.

Bringing an emotional measurement into the development of new products must answer the question of consumers' tests being conducted on non-functional subparts of the product. "Non-functional" means that the consumers cannot use or interact physically with the product because it is only available in the form of sketches, digital representations or pictures. A "Subpart" is a car's smallest unit developed by one team (i.e. a seat, an instrument panel, a multimedia system, steering wheel...).

Research focused on studying subparts of cars mostly deal with the car cockpit. Leder and Carbon (2005) investigated the aesthetic appeal of car interiors varying the perception of complexity, curvature and innovativeness. The car cockpits that were preferred by the participants were the most curved and the least innovative versions. Other researches focused on separate elements of the car cockpit like driving assistance systems (Cahour, 2008; Nass et al., 2005), speedometers and steering wheels (Jindo & Hirasago, 1997), or switches (Wellings et al., 2008). Wellings investigated consumers' holistic experience related to luxury sports car switch-feel. It was found that, in addition to the operational characteristics of the switch mechanism, emotional and usability issues affect the consumers' liking. Desmet and Hekkert (1997), Desmet, Hekkert, and Jacobs (2000), Desmet and Hekkert, 2002, Desmet (2003), conducted many studies on the emotional responses to product appearance. It was demonstrated for instance that car exterior styling displayed on pictures could elicit different emotions. Authors underlined that if the stimuli would have been real cars, other emotions might have been elicited. In fact, appearance of the cars could be modified by scale effects, impacting the pleasing aesthetic properties of the product ("I found it nicer in the picture") and/or the projection in use ("the car looked larger on the picture, I won't be able to store all my stuff"). Although it is specifically emphasized during the assessments that participants should focus on their visual perception of the product, it is difficult to disregard other perceived reasons for liking. Desmet et al. (2000) also demonstrated that, when looking at pictures of the front of cars, subjects can experience combinations of distinct emotions. This can be explained by the complex nature of the product, different aspects of its design sparking off different emotions.

1.2. Emotions in the appraisal theory

Research in the user experience (UX) field developed an approach based on semantic bipolar scales to assess the instrumental and non-instrumental appraisal dimensions of the product (Hassenzahl, 2003). Man–Machine Interfaces such as digital audio players have been particularly studied (Jordan, 1998; Mahlke & Thüring, 2007). In that product context, the instrumental qualities refer to perceived utility and usability of the products. The non-instrumental qualities refer to characteristics of the products that go beyond tasks accomplishment, like aesthetic value, e.g. the perception of beauty, and symbolic value, e.g. the perception of modernity or friendliness. UX authors stated that these appraisal dimensions affect the consumer's emotional reaction and his/her satisfaction.

This approach is of a great interest in the context of new product development as initial briefs, provided by the market intelligence department to the designers, are composed of subjective descriptive words like "modern", "elegant", "fluent" or "comfortable". Understanding the customers' appraisal of such dimensions can help designers in their creative work.

Without any theoretical background, one can propose to group together subparts of the car that are more "hedonic" (car exterior styling, cockpit materials), subparts that are more "instrumental" (trunk or roof box, driver assistance system) and subparts that are "hedonic" and "instrumental" (seat, multimedia system). The last category is interesting in order to study the relationships between the instrumental and the non-instrumental appraisal dimensions and the consumers' emotional responses. Consequently, we have decided to study the consumers' perception of instrument panels. The instrument panel is an area of high importance for the driver interaction with the vehicle as it contains the information about the state of the car. Besides, it is an object in which designers express the general look of the car, i.e. dynamic, sporty, sober, up-market. Pictures of instrument panels will be used as representative of earlier design proposals and the UX methodology will be used to assess their appraisal dimensions.

1.3. Emotion definition and measurement

Dealing with emotions, the first issue researchers had to face is to reach a common definition. Emotions have been studied in various disciplines (psychology, neurosciences, physiology, marketing) leading to many definitions and models. Today, researchers consider emotion as a multi-componential phenomenon with a multi-componential response. The emotion phenomenon can be divided into three major stages: appraisal, preparation of action and response (Frijda, 1994; Ortony, Clore, & Collins, 1988; Scherer, 1982). According to Ekman (1992) and Frijda (1994), the emotional response is composed of four elements: a behavioral component (approach, escape, ...), an expressive component (smile, tears, ...), a physiological component (heart rate, sweating, ...) and an internal component, which is more cognitive, referring to feelings that people can describe: I'm afraid, I'm happy. Every component can be measured, or at least apprehended, thanks to various tools (physiological, facial measures and facial expressions, etc.). Consequently, a consensual definition of emotions can be the one of Scherer (1982): "Emotion is defined as an episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems (i.e. information processing, system regulation, preparation of action, action and monitoring of internal states and environment interaction) to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism." Examples of the words of emotion in literature are pleasure, freedom, interest, anger or sadness (King & Meiselman, 2010; Laros & Steenkamp, 2005).

Regarding the measurement of emotion, various tools have been developed to measure the various types of emotional responses. Psychophysiological techniques like brain imaging or electromyography aim at measuring the immediate and continuous bodily and brain responses. Body movements or prosody are recorded to investigate the behavioral emotional response. Tools like the Facial Action Coding System (Ekman & Friesen, 1978) help analyze facial expressions. However, the only way to access the subjective part of the emotion is to ask participants to describe their experience. To investigate the affective experience of participants, the researchers have developed qualitative approaches based on specific interview techniques and quantitative approaches based on questionnaires. Many criticisms have been directed against self-report techniques, claiming that subjects may not be able to observe directly their cognitive processes and report a priori assumptions or judgments about the extent to which a particular stimulus is a plausible cause of a given response (Nisbett & Wilson, 1977). In fact, the subjects could be unaware of the existence of a stimulus that importantly influenced their response, unaware that the stimulus has affected the response or even unaware of the existence of the response. Despite these acknowledge limitations in cognitive retrieval with the use of self-report tools, self-reports provide an efficient method of assessment of emotions, especially the type of subtle low intensity emotions that are likely to be evoked while looking at a picture or in a design perspective (Desmet, 2003; Laurans, Desmet, & Hekkert, 2009).

When considering self-report tools for the measurement of emotion, the researcher has to choose the underlying emotion model: discrete or dimensional. The discrete approach suggests that a large amount of basic emotions is needed to describe affective states of people (Ekman, 1984; Izard, 1979). There are disagreements between the researchers about the number of discrete emotions, going from 2 to 11 (Ortony & Turner, 1990). Examples of discrete emotions are anger, contempt, disgust, distress, fear, guilt, interest, joy, shame and surprise (Izard, 1979). The dimensional approach suggests that two dimensions (pleasure and arousal) commonly referred to as a circumplex, describe the internal emotional state of people (Russell, 1980). Pleasure is the degree to which a person feels good, happy, contented or joyful in the situation; arousal is the degree to which a person feels excited, alert, stimulated, awake, or active in the situation (Mehrabian & Russell, 1974). In the marketing literature, there is some consensus regarding the bidimensional structure of emotions. The PAD (for Pleasure, Arousal and Dominance dimensions) scale developed by Mehrabian and Russell (1974) is the most commonly used, the dominance dimension being ignored for the lack of empirical studies and the disagreement between the researchers concerning its meaning (Holbrook & Batra, 1987; Mehrabian & Russell, 1974).

As we expect emotions generated by pictures of instrument panels to be of low intensities, we favored self-report scales. Besides, as the product development process is based on verbal requirements, we favored verbal scales. As we aim at introducing the emotional measurement in the earliest phases of the new product development, we need a simple and efficient tool whose data can easily be implemented in the product design specifications. As a first attempt to measure the emotional response of consumers towards a non-functional subpart of a product, we had doubts about the fact that assessors would be able to differentiate between the products according to basic emotions (as defined by Izard (1977)). By combining all the potential emotional responses of the consumers into three dimensions, the PAD scale seemed to be an interesting tool for our purposes. Like in most of the marketing studies, the Dominance dimension would not be used (Ladhari, 2007; Machleit & Mantel, 2001; Wirtz & Bateson, 1999).

The present study aims at answering two questions regarding the emotional measurement in the early phases of the new product development:

(1) Do consumers experience emotions towards a non-functional subpart of a car?
(2) What are the relationships between emotions, appraisal dimensions and liking towards a non-functional subpart of a car?

2. Material and methods

2.1. Consumer recruitment

Consumers ($n = 100$) were recruited for Central Location Tests (CLT) in Paris area, France. They were all drivers of C-segment sedan cars representative of the seven first European brands in mar-

Table 1
Consumers demographic information for the CLT.

Description	Category	Count
Gender	Male	58
	Female	42
	Total	100
Age	20–29	20 (7 males; 13 females)
	30–39	30 (21 males; 9 females)
	40–49	23 (12 males; 11 females)
	50–59	19 (13 males; 6 females)
	60–69	8 (5 males; 3 females)
Vehicle owned	Peugeot 308	13 (9 males; 4 females)
	Audi A3	15 (7 males; 8 females)
	Opel Astra	13 (10 males; 3 females)
	Citroën C4	15 (7 males; 8 females)
	Golf 6	15 (9 males; 6 females)
	Dacia Logan	14 (6 males; 8 females)
	Renault Mégane 3	15 (10 males; 5 females)

ket sales of new cars (Renault, Peugeot, Volkswagen, Citroën, Opel, Audi) with the exception of Ford. In fact, no Ford instrument panel was selected (see Section 2.2) so the seventh group of consumers was composed of Dacia Logan drivers. The perception of the Dacia Logan drivers, who are considered to be more functionally oriented in Western Europe, was a point of interest for the company.

The consumers' age profile corresponded to the mean profile of the C-segment sedan car drivers. The gender split was approximately balanced between the car brands and the consumers' age profile. See Table 1 for details.

2.2. Automotive samples

The automotive samples are eighteen pictures of instrument panels (Fig. 1). We have chosen the instrument panel because this feature includes sensory and cognitive aspects, which are important for the study of the instrumental and hedonic appraisal dimensions.

The instrument panels all come from C-segment vehicles. The C-segment is intermediate in terms of vehicle size and is represented by cars such as the Honda Civic, the Ford Focus or the Toyota Prius. It is a strategic segment for the car industry: it is the largest by volume in the world so C-segment cars have to appeal to a wide variety of consumers.

Surveys are conducted on thousands of customers whatever the vehicle size, its options or its brand and deal with the customers' satisfaction about the purchase, the services and the car itself in the context of usage. This customer data is shared between the European car manufacturers.

Fig. 1. Pictures of the instrument panels used for the CLT.

The survey we selected is carried out three months after the purchase of a new car and is conducted on European car owners. Thirty four European cars were mapped according to the variability of their mean scores on four parameters: interior styling, appearance of dashboard, user friendliness of controls and ease of reading instruments. In order to be representative of the European variability in the perception of the instrument panels, we had to select sixteen products. Two brands were used twice because the cars had been replaced during the year of the test (Citroën C4 and Opel Astra), so the product set was composed of eighteen instrument panels. To ensure that the instrument panels would be perceived as different by the consumers, instrument panels were also selected for their appearance variability in terms of shape (two, three or four dials), colors, and analog or digital displays. There are traditional instrument panels with two or four analog displays and gray or black colors (for instance Audi A3, BMW1 and Volkswagen Golf 6) and innovative ones with one or three digital displays and shiny colors (for instance Citroën C4 2010, Honda Civic and Mégane 3). Digital displays were taken into account for heterogeneity in the products' selection and potentially to elicit various emotional responses.

The pictures of the instrument panels were presented on standard A4 paper size, unbranded and coded with three digit-numbers labels. The instrument panels were switched off, and the specific lights such as open door or oil warnings were hidden.

2.3. Experimental procedure

Assessment of the pictures was conducted through a counterbalanced Latin square design. The test lasted two hours per consumer.

2.3.1. Product samples exploration

Participants were first asked to spend a few minutes looking at all the instrument panels displayed on a board. We wanted to check if they would recognize the instrument panel of their own car to verify if this element would affect their perception. Consequently, participants were asked to remember the number of the instrument panel they believed to be their own and write it down on their questionnaire. If no instrument panel was recognized, participants had to check "my instrument panel is not one of those presented on that board" on their questionnaire.

2.3.2. Hedonic and emotional assessment

The consumers were presented with the pictures in a monadic way.

Firstly, liking of the instrument panels was rated using scores from 1 to 10, where 1 = I really dislike this instrument panel, and 10 = I really like this instrument panel. The 9-point hedonic scale was not used to allow participants to differentiate all the instrument panels using decimal numbers.

Secondly, the product-elicited emotions were assessed using verbal scales from the PAD scale (Mehrabian & Russell, 1974). The PAD contains eighteen semantic differential scales, six for each Pleasure, Arousal and Dominance dimensions. As researchers in the marketing field, we left apart The Dominance dimension due to misunderstandings concerning its meaning.

Since we used a large number of products to ensure the expression of emotions among the consumers, we had to accept a trade-off between the consumers' potential weariness due to the length of the questionnaire and the richness of the measurement. Consequently, we decided to measure the consumers' emotional response in its simplest way using the displeased/pleased scale among the pleasure scales, and the unaroused/aroused scale among the arousal scales. Scores were reported on 5-point scales from 1 = I am displeased to 5 = I am pleased for the pleasure scale and from 1 = I feel unaroused to 5 = I feel aroused for the arousal scale.

Measuring the pleasure and the arousal dimensions with only one scale per dimension means that we accept potential misunderstandings between the consumers about these scales, and consequently that we accept a loss of information. Moreover, the reliability of the measurement of the pleasure and the arousal dimensions cannot be calculated (for instance with the Alpha Cronbach coefficient).

2.3.3. Appraisal dimensions assessment

Participants were asked to rate their perception of the instrument panels according to the semantic differential technique developed by Osgood, Suci, and Tannenbaum (1957). Osgood's semantic differential was designed to measure the connotative meaning of concepts. It is today one of the most widely used scales used in the measurement of attitudes. This technique asks consumers to rate their perception on a series of bipolar scales. We used thirteen 5-point scales whose categories were labeled 'really' – 'slightly' – 'neutral' – 'slightly' – 'really'. The adjective pairs are presented in Table 2.

These bipolar scales were derived from previous tests conducted inside the company on eight instrument panel pictures. In order to collect vocabulary dealing with the consumer perception of the instrument panel, the experimenter selected eight instrument panel pictures according to their luxury, innovativeness and their technology (analog or digital display). Four pictures were common with the initial set of eighteen. Twenty-four employees were interviewed one by one in three steps (8 assessors for the first stage, 6 for the second one and 10 for the last one).

Stage 1: the participants were provided with triads according to the Repertory Grid Technique (RGT) (Kelly, 1955). In RGT, a group of three elements, selected randomly or by specific rules, is presented to the participant, who is asked to specify some important way in which two of them are alike and thereby different from the third. Seven groups of three pictures were presented to each participant in order to test all the combinations.

Secondly, each participant was provided with all the pictures and was asked to group them together and to explain what these groups have in common.

Finally, a sentence completion task was performed: "This instrument panel is in a car that is ..."; "The driver of this car is/looks ...."

This elicitation process yielded 161 adjectives related to the visual appraisal of the instrument panels. This visual appraisal is made of aesthetic judgments based on the visual sensory perception of the instrument panels (colors, materials). It is also made of cognitive judgments based on the consumers understanding of the instrument panels (complexity, readability, presence or lack

Table 2
Adjective pairs used in the semantic differential task.

Adjective pairs
Ugly–Beautiful
Old-fashioned–Innovative
Low-tech–High-tech
Common–Original
Dreary–Magical
Sober–Gaudy
Down-market–Up-market
Professional–Funny
Coarse–Refined
Unfriendly–Friendly
Unreadable–Readable
Complex–Clear
Unreliable–Reliable

of information). The last part of forming the list of bipolar attributes is the matching of adjectives and constructs.

Stage 2: six other participants were asked to group semantically similar words and semantically opposite words and to name these dimensions. Counting how many times each adjective has been grouped into one dimension led us to 13 dimensions. The names of the scales' anchors were the names of the dimensions the most cited by the six participants.

Stage 3: in order to verify that the thirteen scales had the same meaning for the consumers, ten participants were asked to assess the eighteen instrument panels on the thirteen appraisal scales. After they had filled in the questionnaire, they were interviewed on the easiness of the task, their potential doubts on the meaning of the appraisal scales, their perceived relevance of the scales to assess the products and the omission of one or more appraisal dimensions (qualitative responses). These pre-tests confirmed the relevance and the ease-of-use of the thirteen appraisal scales to describe the consumers perception of the instrument panels' pictures.

After these interviews, it appeared to us that ten scales reflect the hedonic appraisal of the instrument panels and three scales the instrumental appraisal (readability; clarity; reliability).

Basic considerations involved in semantic differential methodology deal with:

(1) The simplicity of the bipolar adjective scales. Assessors should find it easier to use scales, which relate meaningfully to the concepts being judged (Heise, 1970). Consequently, pre-tests have been conducted with consumers, and their own words kept for building the scales.
(2) The number of scales to measure a dimension. Considering that consumers would have different understandings of the scales and different points of view about the concepts being tested, more than one scale for each dimension is desirable and generally, four scales per dimension can give adequate sensitivity for most purposes (Heise, 1970). Pre-tests yielded ten scales for the measurement of the hedonic dimension and three scales for the measurement of the instrumental dimension.
(3) The bipolarity of the scales. There are disagreements among the researchers concerning the bipolarity of the scales. Many have tried to demonstrate that combining unipolar assessments yielded bipolar assessments (Vidali & Holeway, 1975). It seems that: (a) some dimensions are bipolar and others are not, (b) some stimuli yield bipolarity and others do not.

Additional socio-demographics were finally collected to conclude the consumer test.

2.4. Data analysis strategy

The analysis strategy has been conducted in order to answer these questions:

- Did consumers experience emotions towards instrument panels presented on picture? The underlying question is: did we manage to measure their emotional responses thanks to the tool we used?
- Are there several clusters of consumers with various emotional responses?
- Which appraisal dimensions affect liking and emotional responses?

Quantitative data collected from the test were analyzed using parametric statistical methods. There are disagreements among the researchers concerning the use of non-parametric or parametric statistical methods to analyze data from bipolar scales. In fact, the hypothesis of bipolarity means that the anchors are linearly at the same distance from a zero point. However, the central point of the scale can be used as an average score or lack of relevance of the scale – the participant cannot evaluate or does not want to evaluate the dimension – (Oetting, 1967). A major limit of the use of bipolar scales is that bipolarity cannot be proven without numerous psychometric tests that were not conducted in the present study. As the scales anchors that we obtained from pre-tests are not logical antonyms such as "reliable" vs. "unreliable" or "friendly" vs. "unfriendly", the risk of non-bipolarity of the scales should be presently underlined. Nevertheless, as other researchers using bipolar scales, we used parametric statistical methods, assuming that the intervals between the scale categories are equal and that the neutral response serves as an arbitrary zero point. Consequently, the categories were replaced by scores from 1 to 5, where 1 = "really" negative anchor and 5 = "really" positive anchor.

The first research question was answered using analysis of variance. Two-way analysis of variance were performed on the factors Product and Consumer for the variables Visual Acceptability, Pleasure, Arousal and the thirteen appraisal dimensions to investigate consumers' ability to discriminate differences in the perception of the instrument panels. The interaction term cannot be estimated due to the lack of replication in the test. However, we can assume that this term has a significant impact in the analysis.

If Analysis of Variance were significant, post hoc Least Significance Difference (LSD) analysis were carried out to establish where significant differences occurred.

Hierarchical Cluster Analysis on liking scores was performed to answer the second research question. Average linkage criterion with Pearson correlation coefficient was used to segment consumers. The Pearson coefficient is not impacted by the data standardization. The widely used Ward's method was rejected because it can be very sensitive to outliers and tends to give clusters of equal size, which may not be useful in the current context.

Finally, a Principal Component Analysis (PCA) was carried out to investigate the relationships between the variables of the test. The average scores per instrument panel were calculated for the variables (liking scores, emotions and appraisal dimensions) for the population and the clusters of consumers. PCA was carried out on the standardized scores of the population appraisal dimensions with the liking scores and the emotions of the population and the clusters as supplementary variables.

As our purpose is a methodological one (and to avoid comparison between the brands), the instrument panels will be coded from D1 to D14 for the analog displays and N1 to N4 for the numerical displays in the Section 3.

3. Results

3.1. Are there significant differences between the instrument panels?

Prior to more detailed statistical analyses, two-way analysis of variance on the factors Product (18 instrument panels) and Consumer (100 consumers) have been carried out to examine the instrument panels' assessments (16 variables). The Product and the Consumer Fisher factors obtained for the visual acceptability, the emotions and the thirteen appraisal dimensions are reported in Table 3. All the tests are significant ($p < 0.01$), so the critical probabilities of the models are not reported in the table. The appraisal dimensions are ranked according to their product effects.

The significant differences obtained for each variable indicate that the consumers managed to differentiate between the instrument panel pictures.

Table 3
Results of the two-way analysis of variance ($p < 0.01$) showing significant differences between the instrument panels assessments.

	Name of the variable	F (products)	F (consumers)
Hedonic Assessment	Visual acceptability	12.4	4.3
Emotions	Pleasure	11.7	2.2
	Arousal	5.7	2.3
Appraisal dimensions	Original	56.2	2.8
	High-tech	50.9	2.8
	Innovative	39.5	3.1
	Gaudy	33.3	3.6
	Magical	30.0	2.0
	Up-market	25.2	2.4
	Funny	22.5	1.9
	Refined	15.3	2.3
	Beautiful	13.5	2.5
	Clear	12.3	3.9
	Readable	11.1	5.7
	Friendly	6.6	2.6
	Reliable	6.6	6.6

There are great differences between the variables as the Fisher value of "original" is six times higher than "friendly" or "reliable" ones. The emotions and the visual acceptability are also less discriminating in average than the appraisal dimensions. Instrument panels that are perceived as different could have identical emotional profiles and identical visual acceptability scores.

Finally, the instrumental appraisal dimensions (clear, readable and reliable) are less discriminating than the hedonic ones. These dimensions may be difficult to evaluate on pictures and people may need to interact with the instrument panels, to use them, in order to know if they can understand and trust the system. Another interpretation is that all the products in the panel were quite similar on those dimensions because manufacturers chose instruments that are optimized on these dimensions or have similar objectives concerning these aspects. The Fisher values for the Consumer factors are the greatest for these three variables indicating different uses of the scales.

3.2. Do the consumers recognize the instrument panel of their own car?

84 consumers reported that they recognized the instrument panel of their own car. Among these consumers, 15 were wrong (i.e. the instrument panel they reported to be the one of their own car was not in fact the good one) and 69 were right.

In order to study the impact of that recognition on the hedonic scores, a factor "Recognition" was added to the data table. It can be 1 or 0, where 1 = this instrument panel is mine and 0 = this instrument panel is not mine. As we wanted to highlight the consumers' beliefs, "1"was written in the data table even if consumers were wrong in the recognition of their instrument panel. Consequently, twelve instrument panels on eighteen have been recognized by one consumer at least.

A three-way ANOVA test on the product factor (df = 17), the consumer factor (df = 99), the recognition factor (df = 1) and the interaction product * recognition factor (df = 11) was carried out on the liking scores.

The product factor ($F = 4.05$; $p < 0.01$), the consumer factor ($F = 4.59$; $p < 0.01$), the recognition factor ($F = 12.42$; $p < 0.01$) and the interaction product * recognition factor ($F = 2.43$; $p < 0.01$) are all significant. The value of the Fisher factor of recognition is three times higher than the values of the Fisher factors of product and consumer, indicating a strong effect of this variable on the liking scores. The average liking scores and the results of the least significant difference (LSD) post hoc test are represented on Fig. 2.

The instrument panel recognized as the one of the consumer always get a higher liking score except for D1 and D5. As only one consumer recognized D1 and D5, respectively, the ANOVA test was carried out with the recognition factor equal to zero in the data table for D1 and D5. The results (not presented in this paper) yielded the same conclusions. The significant product * recognition interaction indicates that the impact of the recognition factor varies according to the instrument panel. For instance, it is higher for D9 than for D2.

3.3. Are there subgroups of consumers with similar liking assessments?

The data table consists of 18 instrument panels in row and 100 consumers in columns. To segment consumers, we performed a Hierarchical Cluster Analysis on the liking scores with average linkage criterion and the Pearson correlation coefficient.

HCA yielded seven groups of consumers, four subgroups of respectively 2, 9, 1 and 2 assessors being composed of consumers with unusual liking, and three homogeneous subgroups of consumers, respectively composed of 24, 35 and 27 assessors (Fig. 3). The distances between the clusters of consumers are important showing important heterogeneity. Nevertheless, this

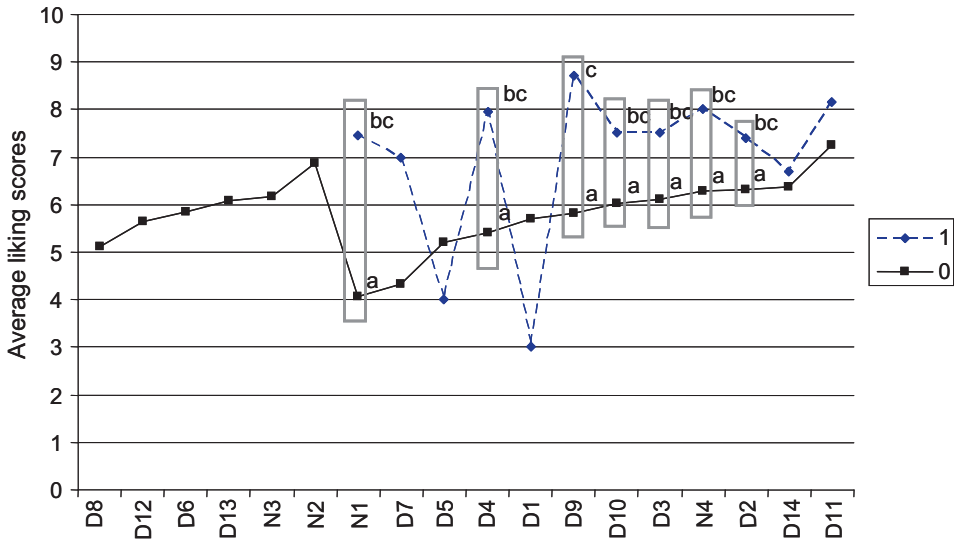

Fig. 2. Average liking scores of the instrument panels when they had been told as the one of the consumers (1) or not (0). The rectangles show where significant differences occurred and the letters indicate the results of the least significant difference post hoc test.

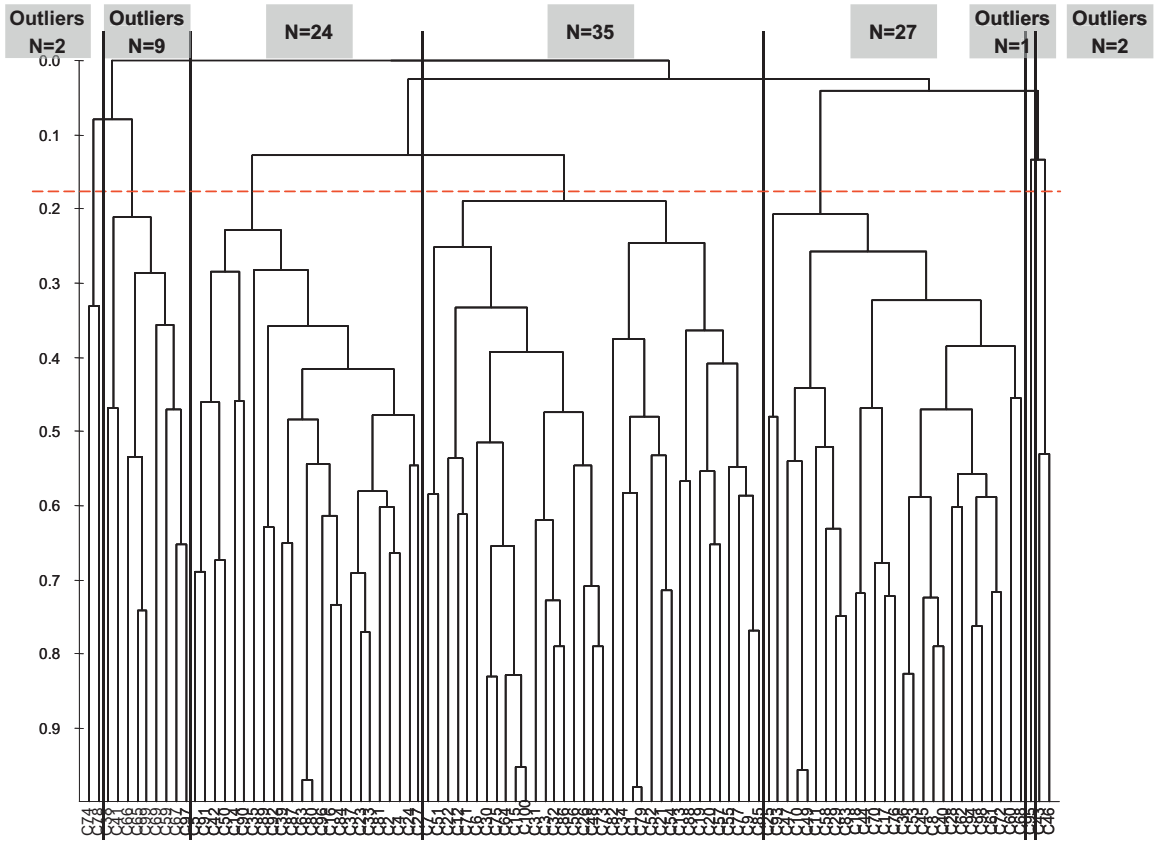

Fig. 3. Dendrogram showing four clusters of outliers and three homogeneous clusters of consumers.

result is not surprising as we are segmenting consumers on their liking of eighteen instrument panels, which is a large set of products.

For further analysis, we only kept the three clusters that have enough consumers to be relevant in the interpretation. In order to verify if the three major clusters that we obtained are relevant, two-way analysis of variance with interaction was performed on the factors Product and Subgroup. LSD post hoc analysis helped establishing where significant differences occurred.

The Product factor ($df = 17$; $F = 12.8$; $p < 0.01$) and the product $*$ subgroup interaction ($df = 34$; $F = 8.2$; $p < 0.01$) are significant, revealing different preferences inside the three clusters of consumers. The subgroup factor is not significant ($df = 2$; $F = 0.22$; $p = 0.8$).

The visual acceptability mean scores by subgroups of consumers and the results of the post hoc LSD test are reported on the Fig. 4.

According to the visual characteristics of the instrument panels, we can conclude that the subgroup #2 likes traditional instrument panels composed of uncolored analog displays. Just the opposite, the subgroup #3 likes innovative instrument panels composed of colored numerical displays. The subgroup #1 is intermediate, liking both traditional and innovative instrument panels.

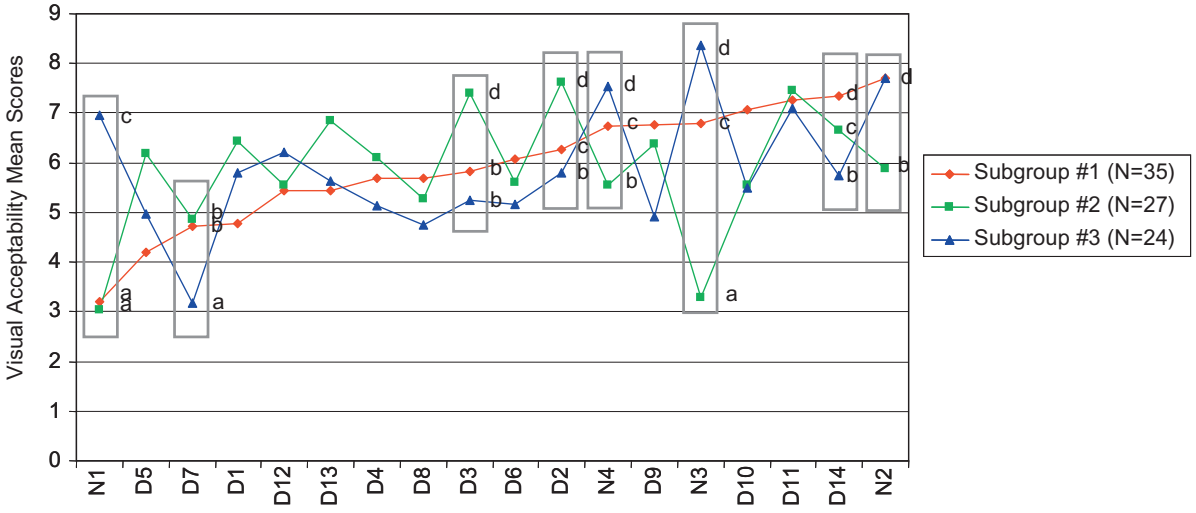

Fig. 4. Visual acceptability average scores of each cluster of consumers. The rectangles show where significant differences occurred and the letters indicate the results of the least significant difference post hoc test.

3.4. What are the relationships between the visual acceptability, the emotions and the appraisal dimensions?

Firstly, we investigated the agreement between the consumers on the meaning of the appraisal dimensions. A HCA (Euclidean distance and Ward criterion since we want to cluster observations and not variables) was performed on the assessments of the 18 instrument panels according to the 13 appraisal dimensions (the data table is composed of 100 rows and $18 * 13 = 234$ columns). The HCA yielded three homogeneous clusters of consumers. The means scores per appraisal dimension and instrument panel were calculated for each cluster yielding three data tables of 18 rows and 13 columns, respectively. Then, a General Procrustes Analysis was performed on the three data tables. The results of this GPA highlighted a moderate agreement between the three clusters of consumers concerning the positioning of the appraisal dimensions and the instrument panels. Taking into account the fact that consumers have been clustered according their assessments of the instrument panels on the appraisal dimensions, the results of the GPA are promising with regard to the agreement on the meaning of the appraisal dimensions.

Consequently, the average scores of visual acceptability, pleasure, arousal and the thirteen appraisal dimensions were calculated by instrument panel. The average scores of visual acceptability and emotions of the population as well as visual acceptability and emotions of the subgroups of consumers were also calculated. All the data were standardized to prevent scales effects.

A Principal Component Analysis (PCA) was performed on the data table consisting in 18 instrument panels in row and 13 appraisal dimensions in columns. The visual acceptability and the emotions of the population and the visual acceptability and the emotions of the clusters of consumers were added as supplementary variables.

PCA revealed two factors with eigenvalues greater than one, explaining 84 percent of the total variance (Table 4). Eigenvectors analysis allows to label Factor 1 "Hedonic" as it carries the innovative, high-tech, original, magical, gaudy, up-market and refined appraisal variables, and Factor 2 "Instrumental" as it carries the clear, reliable, friendly and readable appraisal variables. Beautiful and refined are carried by the two Factors.

Table 4
Eigenvectors, Eigenvalues and percentage of variance of the two first components of the Principal Component Analysis. Factor 1 is correlated to hedonic appraisal dimensions and Factor 2 is correlated to functional appraisal dimensions (values greater than the average in bold).

Variables	Factor 1	Factor 2
Beautiful	**0.253**	**0.350**
Innovative	**0.351**	0.023
High-tech	**0.354**	−0.028
Original	**0.348**	−0.087
Magical	**0.340**	0.106
Funny	**0.312**	−0.075
Gaudy	**0.308**	−0.012
Clear	−0.208	**0.391**
Up-market	**0.334**	0.106
Reliable	−0.088	**0.515**
Refined	**0.287**	**0.217**
Friendly	0.045	**0.366**
Readable	−0.108	**0.491**
Eigenvalue	7.646	3.255
% Variance	59	25

Visual acceptability of the subgroup #1 is close to visual acceptability of the population (Fig. 5). Visual acceptability of the subgroup #2 is close to the instrumental appraisal dimensions (reliable, readable and clear). The Pearson coefficients between the visual acceptability and the appraisal dimensions are respectively 0.83 for reliable, 0.71 for readable and 0.69 for clear and are all significant at the 0.05 level (Table 5). In fact, these consumers preferred the traditional instrument panels (see Section 3.3) which are perceived simple, sober and clear.

Visual acceptability of the subgroup #3 is close to the hedonic appraisal dimensions. The Pearson coefficients between the appraisal dimensions are respectively 0.68 for beautiful, 0.89 for innovative, 0.87 for high-tech, 0.85 for original, 0.85 for magical, 0.77 for funny, 0.71 for gaudy, 0.81 for up-market and 0.74 for refined and are all significant at the 0.05 level. These consumers preferred the

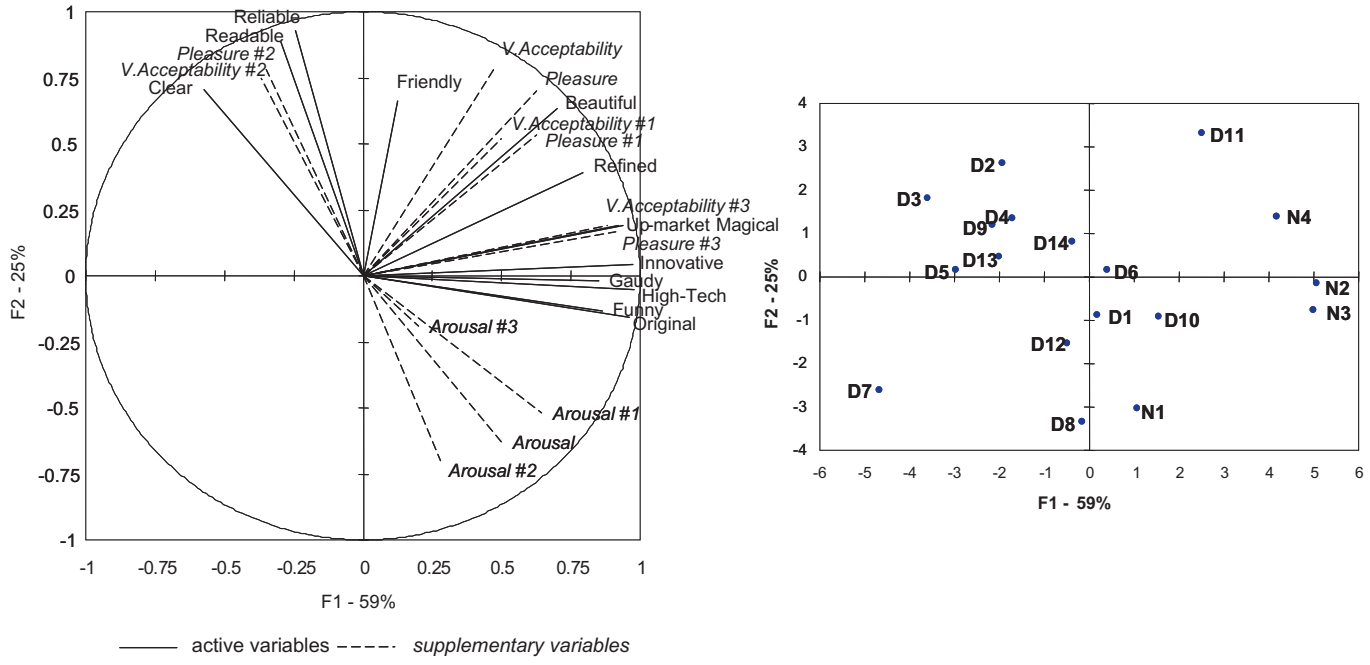

Fig. 5. Principal Component Analysis of the appraisal dimensions. Visual Acceptability and the emotions of the population and the clusters of consumers were added as supplementary variables.

Table 5
Pearson coefficients between the appraisal dimensions and the supplementary variables significant at the .05 level.

Variables	Beautiful	Innovative	High-tech	Original	Magical	Funny	Gaudy	Clear	Up-market	Reliable	Refined	Friendly	Readable
V.Accep#1	0.82				0.65				0.60		0.67		
Pleasure#1	0.92	0.59	0.56		0.75		0.47		0.74		0.79		
Arousal#1		0.55	0.64	0.66	0.54	0.57	0.63	−0.71	0.58	−0.59		−0.51	−0.62
V.Accep#2				−0.55		−0.51		0.69	0.60	0.83			0.71
Pleasure#2				−0.55		−0.51		0.70	0.74	0.84			0.72
Arousal#2								−0.63	0.58	−0.71		−0.60	−0.63
V.Accep#3	0.68	0.89	0.87	0.85	0.85	0.77	0.71		0.81		0.74		
Pleasure#3	0.72	0.88	0.87	0.87	0.91	0.82	0.85		0.83		0.72		
Arousal#3							0.47					−0.54	
V.Accep	0.94				0.66				0.63	0.62	0.76		0.51
Pleasure	0.98	0.57	0.52		0.78		0.56		0.74	0.50	0.83		
Arousal			0.49	0.54		0.50	0.55	−0.68		−0.64		−0.68	−0.65

numerical instrument panels (see Section 3.3) yet perceived as less efficient than the traditional ones.

Visual acceptability and Pleasure are highly correlated for each subgroup of consumers and for the population. The Pearson coefficients between visual acceptability and pleasure are 0.97 for subgroups #1 and #2, 0.95 for subgroup #3 and 0.96 for the population. All the coefficients are significant at the 0.05 level.

In most cases, arousal is opposed to the instrumental appraisal dimensions. This variable had a negative meaning for the consumers who were aroused when the instrument panels were perceived as unreliable, unreadable and complex.

Arousal is not correlated with the visual acceptability (the Pearson coefficients between visual acceptability and arousal are respectively 0.06 for subgroup #1, −0.03 for subgroup #3 and −0.18 for the population and are not significant at the 0.05 level) except for subgroup #2 (Pearson coefficient = −0.72; $p < 0.05$).

4. Discussion

4.1. Hedonic assessment of the instrument panels

From the analysis of variance performed on the hedonic scores (Table 3), it has been shown that consumers had different likings of the instrument panels presented on pictures. Hierarchical Cluster Analysis yielded three subgroups of consumers according to their preferences of the instrument panels.

84 consumers reported that they recognized the instrument panel of their own car, but only 69 were right, which is surprisingly low for people who are supposed to look at their instrument panel often, i.e. every time they are checking their vehicle speed. We have shown that consumers are able to recognize their own instrument panel, and that this recognition affects the liking scores: the instrument panel recognized as mine always get a significantly higher liking score (df = 1; $F = 12.4$; $p < 0.01$). Moreover, this result is also obtained with instrument panels consumers believed to be their own, but they were wrong, which is worse considering the validity of the results. The first hypothesis related to this recognition effect could be kind of reassurance from the consumers (“it’s mine, so I like it”). Besides, neophobia could explain significant lower liking scores for instrument panels that are not much known or unknown. This result is interesting because it can be extended to the traditional marketing surveys where consumers only assess their own car (for instance after purchase surveys as mentioned in Section 2.2). To be compared, the products’ mean scores should be adjusted by this “recognition” factor.

This issue needs further research in order to establish (1) if this recognition effect is linked to the brand of the product and to the brand image and (2) if this recognition effect is the same for all the sensory modalities.

4.2. Assessing appraisal dimensions and emotions of a subpart of a car presented on pictures

From the analysis of variance’s results in Table 3, it has been shown that consumers are able to discriminate between the instrument panels presented on pictures. Liking, emotions and appraisal dimensions yielded significant differences allowing the experimenter to conduct consumers’ tests early in the design process of a new product.

The results of the HCA and the GPA performed on the assessments of the appraisal dimensions highlighted a moderate agreement between the consumers, thus the semantic differential technique seems to be an interesting method to investigate the consumers’ judgments of a product.

The two-way analysis of variance performed on the factors Product and Consumer yielded lower product effects for the instrumental scales (clarity, readability and reliability). This result can be explained by disagreements between the consumers on the assessment of these dimensions or less perceived differences between the instrument panels. The instrumental appraisal dimensions may be difficult to evaluate on picture, as people may need to interact with the product. All the products in the panel may also look quite similar on those dimensions because manufacturers chose instruments that are optimized on these dimensions or have similar objectives concerning these aspects.

Principal Component Analysis performed on the appraisal dimensions yield two factors explaining 84% of the total variance (Fig. 4.). The appraisal dimensions can be grouped in two constructs namely Hedonic and Instrumental, as established by the theoreticians of User Experience (Hassenzahl, 2003; Mahlke et al., 2007). The variable Beautiful is correlated to the first two axes (the hedonic one and the instrumental one) and to the visual acceptability and the pleasure of the population and cluster #1. This result is consistent with Hassenzahl (2004) who considers Beauty as a global evaluative construct having strongest correlations with the overall assessment of the product than hedonic or instrumental attributes.

The visual acceptability was correlated to the appraisal dimensions of the instrument panels for the population and for the subgroups of consumers. Some consumers are particularly sensitive to the hedonic characteristics of the instrument panels (subgroup #3) or to the instrumental characteristics of the instrument panels (subgroup #2). However, the biggest cluster in number of consumers (subgroup #1; $n = 35$) is interested in both instrumental and

hedonic characteristics of the instrument panels. These results and the analysis of the qualitative data from the consumers (not presented in this paper) allowed the experimenter to make specifications to the designer.

The emotions Pleasure and Arousal were not linearly correlated, as established by PAD authors (Mehrabian & Russell, 1974). Pleasure is strongly correlated with visual acceptability for the population and for each cluster of consumers. This result led us to the assumption that these two variables were the same for the consumers. At this stage of the research, we do not know if this result is due to (1) the type of product (i.e. subpart of a car presented on picture) or (2) the methodology selected to record the data. In fact, as we only use one scale to measure the pleasure dimension of the PAD, there may be a subtle distinction between the liking properties and the pleasing properties of the instrument panels. Using all the scales from the PAD (six scales to measure the pleasure dimension and six scales to measure the arousal dimension) to record the emotional response should provide an accurate measurement of pleasure, potentially distinct from global appraisal of the product. Tests are being conducted to compare the results obtained from the original PAD (twelve scales) and results obtained with a reduced PAD (two scales).

The correlations between arousal and the appraisal dimensions highlighted that arousal may have different meanings for the clusters of consumers (Table 5). Moreover, arousal seemed to have a negative meaning in average for the French consumers we interviewed (consumers are aroused means that they feel stressed because the instrument panel is complex, unreadable and unreliable). Again, using larger number of scales to measure the arousal dimension should provide results that are more accurate.

4.3. Towards process and design specifications

From this research, it is hoped that the benefits of the measurement of emotions early in the design process has been persuasive. In fact, in the context of new product development, only the consumers' liking is usually taken into account in the consumer studies. However, considering not only the consumers' liking but also their emotional responses and attitudes towards the product yielded comprehensive data.

Nevertheless, emotional measurement when applied to new product development should provide:

(1) An understanding of what drives consumers' satisfaction, i.e. the relationships between liking, emotions and the appraisal dimensions of the product, in order to make specifications to the marketing intelligence department. This consideration gives weight to holistic approaches for future investigations of consumers' perception.
(2) Concrete specifications helping the product designers in their creation work, i.e. the relationships between technical characteristics of the product and consumers' emotional responses. Answers to this expectation are complex as cars, or even subparts of cars, are composed of many elements. Besides, the interactions between cognitive and sensory aspects of the product must be taken into account. Sensory science techniques combined with design of experiment techniques could be an interesting direction for future research.
(3) A tool and a process to take into account the emotional measurement in the car design process. This study showed that emotional responses could be obtained early in the design process from consumers' tests conducted on pictures. Moreover, emotional responses towards subparts of cars have been measured. However, further research is needed to investigate the relevance of the emotional responses obtained from pictures vs. real products. Sensory science techniques could be of a great help to study the perception variability between a product presented on pictures and a real product. Finally, further research is needed to understand how an emotional reaction to a subpart of a car would affect the car global appraisal.

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