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HANDLING SUBJECTIVE PRODUCT PROPERTIES IN ENGINEERING, FOOD AND FASHION

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1. Introduction

Design processes are driven by the requirements that they need to meet and the constraints that the products, design processes and organisations are subject to. Many of the resulting product properties can be assessed objectively, but many products across a range of domains have very important characteristics that are not objectively assessable through direct measurements or simulation models. In engineering design these include properties like handling ability or engine noise in car or trucks. These properties affect the consumer perception of the product and are some important factors buying decisions and brand perception. Engineering companies find these properties often harder to handle than objectively measureable properties, such as emission or fuel consumption. While in engineering these subjective properties are important factors that influence design processes and create a certain degree of process iteration, subjective factors play a much more important part in other design domains such as food and fashion. This paper contrasts engineering practise with our observations in the food industry, which relies very heavily on user and expert panels, and the fashion industry, which trusts the assessments of professional designers and rarely interacts with customers; and reflects over lessons that could be learned for engineering design.
After discussing design methods dealing with subjective properties of products in section 2, the methodlogy of our research is explained in section 3. The domains of automotive design, food innovation and fashion design are discussed in terms of their contexts, players in the design process, constraints and the way subjective properties are handled. Section 7 draws a comparison between the three domains in terms of the elicitation of customer expectations, the role of customers and other designers in the development process and the evaluation of subjective properties.

2. Subjective factors across domains

Design research has made great advances in understanding the emotions of product users and in developing tools and methods to understand, model and support an emotion-focused design process [Desmet and Hekkert 2009]. This has largely focussed on consumer and user needs and appeal of consumer products. User-centred design approaches aim to integrate the users as a participant in the design process so that they can provide responses to the product immediately and directly.
By contrast Kansei engineering methods [Nagamachi 2002] make subjective properties explicit by relating physical attributes and perceptual attributes. This research aims at exploring the structure of emotions by building a database of consumer feelings. From the consumer point of view, a *forward mapping process* from perceptual words to design elements is established, and from the designer point of view, a *backward mapping process* from drawings to perceptual words is proposed. While this gives designers a handle on how they can express subjective concepts, Kansei engineering does not

quantify emotive concepts and provides little guidance as to how the concepts are implemented in detail. Kansei engineering supports the understanding of subjective properties, but the process of translating these into physical properties of products remains tacit, and thereby does not support the assessment of subjective product properties. Kansei approaches have been applied to engineering design, for example Jindo and Hirasago [1997] used Semantic Differential Method (SDM) to the design of car interiors. A combination of these methods is proposed by Petiot and Yannou [2004] for gaining a rough understanding of the structure of emotions of vine glass users, specifying an objective glass to design by comparison with existing ones, and assessing design proposals under several perceptual properties. Again the reasons for emotions and perceptions were not well understood.
More sophisticated methods based on genetic algorithms, neural networks, fuzzy logic and Bayesian networks have been applied to ensure mappings between perceptual words and design elements, but these systems are often opaque for designers and consumers. For instance, Ben Ahmed and Yannou [2009] used Bayesian networks to learn from user experiments probabilistic relations between perceptual attributes and technical characteristics of car dashboards. Hsiao and Wang [1998] applied a semantic transformation method to automotive form design, allowing an automatic adaptation of the shape to the required image. Product semantics, the "study of the symbolic qualities of man-made forms in the context of their use, and application of this knowledge to industrial design" [Krippendorff and Butter 1984] is an important challenge in product design. Never the less, because of subjectivity, this particular dimension of user needs is difficult to express, to quantify and to assess. Previously used methods have been developed have been limited to some perceptions or subjective properties or to a part of a product.

3. Research methodology

This paper has resulted from numerous discussion of the authors on the similarity and differences between design domains arising from our interest in driver of design behaviour [Eckert and Stacey 2014] and innovation pattern across industry sectors [Bertoluci et al. 2013], which led to the realisation that subjective properties are handled in very different ways in different industry sectors. Simulating noise properties as early as possible in the design process has been investigated by Hamdi et al. [2006]. It has been showed that even if it is possible to express by equations aggregate noise performances that car users are sensitive to, it is not easy to accurately assess them early in the design process from individual car components with vagues dimensions. Their contribution to the whole perceived noise can not easily be added. Despite theoretical efforts, noise simulation in a car is only possible late in the design process, at best on a digital mockup. The issue of describing subjective properties was also an important theme of recent studies on testing in diesel engines [Tahera et al. 2013] and design margins in engineering design [Isakson et al. 2014]. In both studies we carried out a series of 17 and 10 interviews respectively. The studies on the food industry concentrated on two objectives, sustainability [Olsson et al. 2013] and innovation [Jomaa et al. 2011]. Berloluci et al. [2013] conducted semi-structured interviews with 9 people in charge of R&D or of Innovation or of marketing in 7 large French and international food enterprises. to ask about their definition of the innovation, the functions of innovation in the process, how they shared the actions and responsibilies in the innovation process and what sort of data and information they exchanged. The results of these current studies were compared against findings from studies we carried out in the fashion industry in the 1990s, where we interviewed and observed knitwear designers in 25 different companies to study the use of sources of inspiration and design communication. In Eckert and Stacey [2000] we describe the methodlogy of these studies, and argue that designers justify their designs by implicit references to other designs. In understanding how subjective properties are handled, it become clear that the differences lie in how the different sectors interact with customers throughout the design process and how much objective measurement and expert judgement replaced user feedback. Therefore we compared the design processes and key decision points and mapped systematically how and when the design process engages with customers. Rather than providing qualititave data, which would be nonsensical in heterogeneous industry sectors like engineering, food or fashion, the aim of the paper is to show different ways of tackling a similar problem across sectors and explain why each of these are rational responses to the properties of each domain.

4. Automotive design

Subjective assessments are an important aspect of assuring that the vehicles appeal to the customer. It is not enough for a car to meet its technical requirements, it must also portrait the right image and the consumer must like it or be attracted to it. A car is to some extent a fashion product and car companies must update their cars to avoid creating a dated looking car. Consumers are attracted to different elements of the design of a car. While many of these properties are styling properties, for example the shape of car head lights, others such as car handling or noise are the results of the interaction of complex technical features. Other automotive products like trucks or road vehicles are often not purchased by the people who drive them, but are used for very long periods of time and the well-being and comfort of the drivers is critical to them carrying out their tasks successfully.

Noise is particularly critical in vehicles, because it is also affected by factors outside the control of the car designers such as road surfaces or environmental conditions. Engineers aim to minimise the overall noise in a car, while creating a sound that is both reassuring for the driver and characteristic of the brand. Besides engine noise designers are concerned with other noises such as the sound of closing doors or wind screen wipers.

Outside of specific car development projects, R&D projects go on to create new engines, which meet emission requirements with minimal fuel consumption, and to generate innovations for other parts of the car. Based on the results from R&D, car companies work on more advanced concepts of cars. Car companies exhibit concept cars at car shows to showcase their newest technology combined with new styling of cars. This is a first opportunity to gain a critical review of potential styling features. However factors like handability or noise cannot be picked up with concept cars, because they depend on the detailed implementation. While concept cars can drive, they normally are displayed rather than driven under different circumstances. Marketing department analyses market responses to existing designs and identifies opportunities for new models. If a business case can be made, the concept for a specific car is developed, which defines the overall characteristics of the car. If this car passes the relevant gateway it is developed for series production, where concerns and platform issues need to be considered. Only when the details of the design emerge these subjective properties, like noise, handlability or driver confort can be assessed.

Car companies run focus groups with potential customers to elicit requirements for a car as well as brand and product characteristics that appeal to consumers, for example “masculine” or “sportive”. These properties need to be translated into technical specifications for designers to work with. The logic behind this translation process is often not revealed to the designers who later have to implement these concepts, and different people assess the characteristics later to those who specified them and might be able to assess them holistically. In some companies in the automotive industry the requirements for these subjective characteristics are set by the same team that later evaluates them, while in others this connection is not kept.

The evaluation and testing of product properties is a highly structured process, which runs in parallel to the design process from the beginning. Throughout early phases key performance parameters of the car are tested using mock-ups of the entire car, for example for aerodynamics. Individual components are tested in house or with suppliers. Tests often have to be scheduled a long time in advance, because space on the testing rigs needs to be allocated so that testing and design cannot dynamically interact.

To evaluate a product the companies identify suitable parameters of the product that they can measure and for which design tests can be defined. As far as possible they are trying to treat subjective factors in a similar way to objective characteristics by identifying a set of suitable objective parameters that they can measure. For example to assess handling they place a number of sensors on the stirring wheel and the interface to the power train and measure the responsiveness of the vehicle to different kinds of handling. Test drivers also assess the vehicle on the whole and rate its handability under different drive situation on a scale. These two values are then correlated to each other. If there is a discrepancy between the subjective and objective assessment of the vehicle they look for potential explanations to identify places where they can take further measurements. Noise is measured in a range of circumstances, but relating the measured noise levels to the experienced noise can be extremely difficult. Special noise engineers address this by listening to vehicles and analysing the noise, so that they can suggest engineering changes to improve the noise levels.

These whole project subjective characteristics are very problematic in design processes mainly for two reasons. Since they affect the entire product it is not possible to assess them before there is a realistic whole product prototype, which is only available late in the process, when changes are costly and problematic. The effects of changes in these characteristics can be extremely subtle so those earlier versions only provide a vague impression. The second reason is that these properties are very difficult to simulate in a virtual model as a whole. To date virtual testing can calculate the objective values of product parameters, but since these are often not sufficient the subjective characteristics can only partially be assessed.

5. Food innovation

In developed countries the food market is extremely competitive and innovation largely in production processes is a key element of the enterprises' strategies, but typically not shared with the consumer.
Each year numerous new food products are launched, for example in France, between 2008 and 2009, 18% of the offer consisted of new products. However, many food innovation result in failures. Withdrawal of products from the market after one year reaches up to 70%. The majority of these new products are extensions of existing lines, e.g. changes in the size change of drink bottles or addition of new flavors, which require extensive work of redefining formulations and investment on the production lines, but do not appear as tangible innovations to consumers. In the formulation of the food, producers need to generate reliable flavors and textures in spite of variations in the raw materials such as variations of water or of starch percentages in the ingredient which could altered the structure or the organoleptic properties of the food), and test these as objectively as possible. They also break these subjective factors down into objective factors that can be measured and assessed by both expert and consumer panels.
In the large food companies we studied the innovation process follows a stage gate process to assur that the following constraints and expectations are met:

- Organoleptic qualities of the product (appearance, texture, taste, smell, flavour...)
- Practicality (time and way of consumption, utensils used, preparation required, way of conservation or storage, packaging related services...)
- Safety assurance (origins of ingredients, microbial risk associated to the food, the packaging and their interaction, the storage mode and shelf life...)
- Atmosphere expected that comes with fun, exotic, friendly feelings...
- The willingness to pay of the customer and the market part interested by the product
- Technical feasibility at the production line scale

The marketing department is responsible for defining the product and market briefs. They follow a strategy built on studies of sales, competitor analysis and more predictive markets surveys taking into account sociological changes resulting in changing patterns and content of consumption, such as the disappearance of family meals, reduction of the family size and looking for healthy foods. The marketing department represents the voice of the customer in the company at the beginning of the innovation process and is in charge of creating some social reference points for the product to increase its level of acceptance by the consumer. Large companies deploy focus groups or quantitative studies to increase the wealth of the initial briefs defined by the marketing department.
The R&D department turn this product brief in product prototypes which are evaluated by marketing but also by some customer in a part of the interviewed enterprises. At the end of this formulation step best practice involves target consumers through panels which compare the qualities of the new product with those of existing products. The next tests of the product are conducted at the end of the preparation for mass production because the organoleptic characteristics of the product can be affected. Often the product is directly tested in the market by introducing it in one or two stores.
Besides meeting a primary need, food becomes essentially a source of pleasure in both subjective ways, like taste and objectively assessable way, like providing a basis for healty nutritions but also very personal ways, like the satisfaction in preparing food for the family or the memories associated with an ingredient or a dish.
During formulation (i.e. the determination of the recipe), the R&D function uses many objective criteria to rate prototypes and define ways of improving the recipe. Some criteria are defined by

regulation or technical constraints. The properties of food are highly connected, for example the quantity of sugar in a cake will have an influence on its taste but also on its structure and therefore on the sensations perceived during mastication. This quantity of sugar will have also an influence on the acidity of the product and consequently on its natural capacities to limit the development of the microorganisms, which are a sanitary risk. A recipe is a compromise between all these characteristics of different types and magnitudes, which cannot easily be ordered.
Some of these characteristics, such as acidity, hardness, nutritional value, ratio of specific nutriments are clearly objective. They can be named, instantiated and their values are set in advance. Tests and charts measure and calculate their actual values. Models of the physicochemical behaviour also predict some of the behaviour of the mixtures due to their compositions and the heat treatments they undergo. For example when creating chocolate chips at first it is impossible to predict the interactions on the organoleptic characteristics of the ratio of sugar and chocolate, the size and their colour. It is even harder to predict how the perception of the colour of the chocolate will be affected by the colour and texture of the dough in which they are embedded, and what the overall smell will be.
The perception of the organoleptic qualities of the food product is experiencial. The experience is created by the moment of consumption and affect by many incidental factors, like the welfare of the person who eats, the behaviour of the other people around, the temperature, colour of room and its smells, comfort, the time available to eat, time since the last meal, etc. The experience is also influenced by cultural references, personal stories or the desire to find or avoid a memory. For example, after the Second World War in Europe, nobody wanted to eat vegetables associated with the war. Similarly it is almost impossible in France for the luxury grocery stores to offer organic and ethical products, as they are considered by their customers of insufficient quality, while many British customers buy organic food, in particular vegetables because they expect organic food to taste nicer.
The interaction of all these characteristics associated with the product, the consumer and the conditions of the experience of consumption makes it difficult to establish the real value of the food prototypes first created in the laboratory and later in the manufacturing plant. The only real definition of the quality is the tests conducted in consumer panels, however these occur under controlled circumstances and therefore loose the situatedness of food consumption. Market trails can measure the speed with which a product sells, but cannot assess the reasons why it sells.

6. Fashion design

There have been very few real innovations in fashion over the last century. Most garments are still produced on a sewing machine. Knitting machines have now caught up with the versatility of hand knitting. Digital printing is currently opening up many new possibilities for design, because it avoids the costly production of printing screens. Designers are inspired by new technologies. However, the high street typically only picks up on new innovation or radically different designs, if these are seen to have succeed in designer collection or niche labels.
Technological innovation is one factor that drives the renewal of fashion. Most of changes in fashion are subtle reflections of cultural changes or the adaptation of fads or features across the industry. New themes for fashion collections come from diverse sources such as films, exhibitions, anniversaries, particular geography regions etc.
Fashion is fundamentally referential of other fashion as well as wider cultural phenomena. Fashion can be thought of as a trickle down process where fashion leaders, typically cat walk designers, propose new themes often picking up on historic designers. These are then taken up by the high end high street fashion and with a certain delay by the mass high street labels. Before cheap mass fashion brings a style to an end. In Eckert and Stacey [2001] we describe in more detail how the space of acceptable design moves on (see figure 1).
Fashion appears as a remarkable coherent whole when looked at across all the garments offered for sale in a shop. This is achieved by all designers and to same extend buyers picking up on similar trends and looking at similar designs as reference designs, rather than through direct interaction. For each company the goal is to produce a range of garments that fits within this wider context of fashion at a point that is suitable for their target customers. Some company position themselves at the cutting edge of fashion and everything that has already been seen some months previously looks dated, while

other company pick up on trends that are well established and translate them to the style of their own customers.

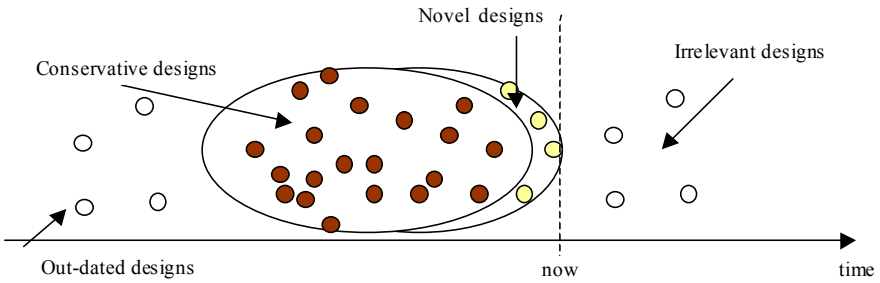

Figure 1. The envelope of acceptable designs within a fashion from Eckert and Stacey [2001]

While there is coherence amongst garments at any one time there is also a lot of freedom and flexibility in the details of the design. Designers can create the appearance of coherence through colors, shapes or textures while being free to design other aspects as they like. Fashion is rarely described in objective criteria beyond broad categories of garments or features (e.g. round collar shirt). The details are choices of the designers who need to judge the appropriateness of the style. At the same time fashion is subject to very tight price points with low profit margins.

The fashion design process reflects the referential nature of fashion design. It is remarkably similar across companies at very different points in the market. The process begins with designers researching the trends and styles of a new season or entry point into the market. Very early most designers receive indications of target trends from internal or external buyers which are usually just a few words (such as butterflies or Russian military clothes) setting a direction. From this, designers look more specifically into clothes coming out that fits these themes as well as other images relevant to the theme. They put this together into a mood board – a collection of found images, maybe sketches and fabric or wool samples. Once the themes are agreed, they typically select the majority of the fabrics or yarns they are using for the theme and get started in developing ideas for specific garments. There are assessed in an internal selection process by groups of designers maybe in conjunction with internal buyers. The selected designs are prototyped usually in house or by the manufacturer. The garments are selected by the buyers based on prototype garments. In the design process very large numbers of designs are discarded, a ratio of 200 ideas to 50 samples to 20 designs would not be untypical. The selected garments are then manufactured usually by offshore suppliers, who have little input into the design. The garments then enter the shops and are either marketed directly by the design label or the retailer.

Apart from the price and manufacturing constraints, design evaluation criteria are not stated explicitly, but are deeply tacit in the understanding of each designer. The designers acquire a degree of shared understanding of the aesthetics of a season by systematic process of learning about other designs. This process fine tunes their perception, but does not involve making the characteristics explicit. The talent of a fashion designer lies partly in recognising how they can push the envelope of acceptable designs while not alienating their customers.

Designers discuss designs and design ideas with each other, but often through the short hand of references to other designs. In design critiquing sessions, evaluation is rarely explicit, but expressed through a degree of enthusiasm. It is important to designers to “believe” in their designs and “defend them” against criticisms. Through this process, garments are selected.

The end customer has remarkable little input into the design or assessment of a particular design. Designers often only have a vague idea of their target customers and some designers create personas for which they are designing, in the absence of purchasing data. Sales figures are usually not broken down to individual garments and arrive when the designers are already working on the following year’s collection. Some companies only have the order numbers from retailers, but do not know how quickly the garments have been sold or whether they had to be reduced in the sales. Some fashion brands, such as Zara, have a much closer loop between design and retails, as they produce fast fashion

for their own stores. However, even if designers get sales figures for individual designers, they do not know why a particular design has succeeded or failed.
This places a very prominent role on the designer in the evaluation process. In the absence of objective factors, the designers believe in the product and their reputation as a design play an important role in the selection of garments during the design process. Similarly the customer uses the brand or name of the designers as a guide to whether a particular design is fashionable or not. Price has become a very important selection factor for garments. As garments have become cheaper, price differentials have become more important; and at the same time consumers care less about individual garments than they did when a garment was considered as an investment.

7. Comparison between different domains

The descriptions of the design and development processes and of the handling of the subjective properties of the products show the diversity of the practices between the different industries. The different industries follow roughly the same process of conducting general market research before embarking in the design of a specific product. The designs go through an evolution from a concept to a production prototype, which is then produced and launched on the market, as illustrated in Figure 2. Table 1 shows who carries out validation in the different phases of the process in different domains.

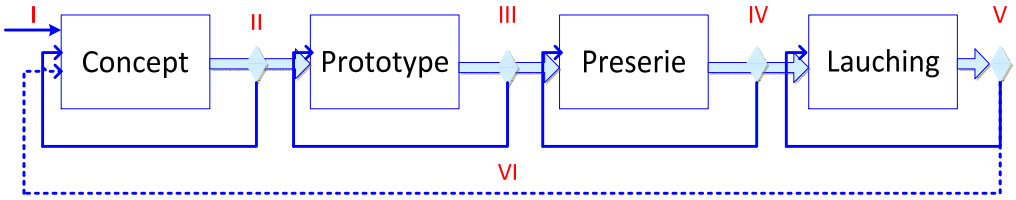

Figure 2. Position of criteria analysed in the design process

Table 1. Overview of subjective assessment through the design process in different domains

Phase	Pre - Project	Concept	Prototype	Preserie	Lauch/ in Market
code	I	II	III	IV	V
automotive	Market research Consumer panel	feedback on concept car	Designer / peer judgement		Sales figures, dealers
food	Market research	Expert/consumer panel	Expert/consumer panel	Expert/consumer panel	Sales figures
fashion	Trend research	Designer /peer judgement			Sales figures

The fashion processes place the largest emphasis on general market research through which the designers develop their tacit perception of the current styles. Fashion garments are usually sampled on production machines or machinery that does not require a change to the design to scale it up to production. The designer and the designer's peers are the judges of the appeal of the garments. Fashion companies have meetings where each of the designs is discussed and the designer can send the design. In these meetings most judgements are very impressionist without providing a detailed explanation of why a particular judgement has been passed. During a normal working day fashion designers look at each other's designs and usually comment on what they particularly like. Sometimes this is repeated when the formulation has been adapted for the specific manufacturing process. The final product is sometimes trailed in the market with a small range of stores. In automotive design consumers are mainly involved at the beginning of the process when the market needs and opportunities are assessed and a concept car is presented to the wider public. During the development of the vehicle, the evaluation is taken over by specialised engineers in the company, who was built specific expertise for a particular subjective property. For example car companies have a noise team. In addition test drivers provide feedback on the car. The product in market is then critically reviewed by the press and the companies can access consumer feedback trough their dealer network. The food

industry has the most systematic process of engaging the user desires and perceptions. In Table 2, we pick up on the stages of consumer interaction in the food industry and analyse what is going on in the other two sections that is replacing the direct interaction with consumers. This analysis is not the description of a precise case in each technological area. One can read it as a general synthesis of the different elements from the studies evoked in section 3.

Table 2. Comparison between food, fashion and automotive design

		Food Design	**Fashion Design**	**Automotive Design**
	Consumer expectations	Sanitatory security, good ratio pleasure/price	Fashionable product, suits personal style, good quality and price	Meeting requirements, projectiving a suitable image, reliability
I	How are they elicited?	Market surveys analysis, analysis of stores sales, social survey, analysis of social trends. regulation (evolution), technology push	Study of trends from leading designers and trend forecasters, celebrities and their portrait in the media;technology push.	Focus groups with customers, market analysis, discussions with dealers or lead customers
	Who does it?	Marketing *Research &Development*	Trend forecasters, leading designers articulate cultural trends	Marketing, Customer facing engineering. Early design teams
	Who develops the concept?	Marketing	Designers, some retail buyers	Designer, Marketing, Trend consultants
	What sort of definition is used?	Brief with consumers insight(s) & commercial objectives.	Brief verbal description, with the assumption that many designs disgarded.	Verbal descriptions, technical specifications
II	Are customers considered in the concept test ?	Sometimes a test of concept with the segment market.	No	Sometimes
	Who develops the prototype?	R&D with Buyers.	Fashion designers	Engineers
III	Are customers are considered in the prototype test ?	Sensory test is the rule. They are not always conducted with the target market.	No	Mainly through engineers
	Who develops the industrial preserie?	Industrialisation functions and/or Quality function.	There is only one prototype, sampling on production machines	Specialised engineers
IV	Are customers considered in the preserie test?	Rarely, genaraly Quality function and the Marketing are in charge of these tests.	No	No specifically
V	How customer's feedbacks are taken into account?	Sales volumes, consumer panels. Some focus groups can be conducted.	Normally very little customer feedback	Sales figures, careful assessments when the product does not sell as required

8. Discussion

The cases of the food innovation process and of the acoustic performance of a vehicle are representative of two situations extremely different in terms of design complexity. However, both require a definition by marketing which tries to capture the subjective properties of the new product and to allow a translation into expected quantitative and qualitative properties of the product. But these definitions only provide guidance for the food R&D so they create the product to satisfy the technical

needs and evaluate the subjective properties of the product through tests of its prototypes with some consumers or their representatives: the marketing managers. These tests evaluating separate organoleptic properties are very analytical and might miss the overall appeal of the product in context. Using the Principal Component Analysis method finds combined influences, e.g. the interactions of the structure of the product and its colour. This method is descriptive rather than prescriptive and reduces rather than explores the complexity of the organoleptic experience. This dichotomy between subjective experience and the objective measurement and description is also at the heart of the challenges engineering companies face with assessing subjective properties. They test the properties a product has, rate them and correlate them to measurable parameters. This does not necessarily give them a repeatable procedure to define the product characteristics for future products. At the front end of the process, the interpretation of qualitative product characteristics to create a product specification depends on the skills of a small team in an engineering company, and is not well understood and systematised.

Many subjective properties of a product are whole product characteristics that arise through the interaction of many diverse factors in the product. They are subject to subtle changes in the product definition. Therefore these properties are hard to predict at the beginning of the design processes and can only be assessed by human experts late in the process largely through physical testing. This is reflected in the processes in the textile industry, which do not even attempt to even make these product characteristics explicit let alone measureable and trusts the judgement of the designers.

This illustrates that we need methods that combine the intuition of experts with a systematic way of working. In Petiot and Yannou [2004] we propose a general approach to assess product semantics in a sound way. It is based on user tests, and involves several classical methods from marketing and decision-making theory, as multidimensional scaling, semantic differential method, factor analysis, pairwise comparison and Analytical Hierarchy Process. As a result, our integrated approach provides designers with a tool which helps them to understand and specify the semantic part of the need; it rates and ranks the new product prototypes according to their closeness to the specified “ideal product”, and it underlines the particular semantic dimensions that should be improved. We showed by this approach that we did not need sophisticated measurement scales for each semantic or sensorial dimension.

These analytical methods do not work in complex situations like those we refer to (emotional/sensorial car design, fashion design and food design). These four reasons are;

1. The heterogeneity of factors and people concerned by a preference (assumed to be the only representative subset of customers in the only purchasing situation, for analytical methods)
2. The number of factors we should take into account (limited for analytical methods)
3. The necessary trade-offs with design processes, costs, know-how, available productive technologies... (not taken into account in analytical methods)
4. The fact that decisions are made along a timeline (absolutely not taken into account in analytical methods where data are supposed available at the time the decision must be made)

Therefore in the three industrial sectors we studied, the intuition part of need specification is critically important together with the consideration of customers at some points in the design process timeline.

9. Conclusion and further work

In this paper we clearly state that, despite the progress in making subjective product properties objective and quantifying them made by sophisticated Kansei type methods see Petiot and Yannou, [2004], it is illusory to believe that one could express a unique and unambiguous set of requirements from the beginning of a development project and that we can get rid of both designers’ intuition and customer feedbacks along the product development timeline. In summary there are four reasons: heterogeneity of factors and customers, number of factors (cultural ones have been mentioned for all sectors), necessary trade-offs within the company and decisions made progressively along the product development timeline. Our study of the three industrial sectors: automotive design (especially acoustics and driving comfort), food design and fashion design are very different in the nature of actors and information that influence the ability of the product design process to integrate the subjective properties of a product, as shown in Table 2. Each sector has its own habits and rules to consider requirements, ideation, prototypes and customer tests, preserie and customer test and product

launch. Further investigations are required allow to better understand why design practices may be so different in different industrial sectors.

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