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THE AESTHETIC AND PERCEIVED ATTRIBUTES OF PRODUCTS

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Abstract

The performance of a product – technical, aesthetic or perceived – is determined by its *attributes*. Technical attributes of a product, such as its weight, power, scale, efficiency, cost and the chosen material or manufacturing technologies can be measured or expressed in standard, accepted, ways. The character of a product depends on more than this – its technical attributes are a part, but so too are its aesthetic or perceived attributes. The *aesthetic attributes* are those to which the senses respond: touch, sight, sound, smell and even taste. *Perceived attributes* of a product – its style and its symbolic associations – are subtler but no less important; it is these that create its delight and give a product its personality, so to speak. In some way, these attributes – of aesthetics and perception – are related to materials but they are more easily spoken of in products. Here we seek to establish whether a general vocabulary for discussing aesthetics and perceptions in industrial design can be established and then assigned to specific products or materials. We do this by surveying design reviews, museum exhibitions and other commentaries on products, searching for a common language; in conjunction with this survey, we measure the responses of a test group to selected products with regard to this language. The results indicate general agreement when assigning key aesthetic and perceived attributes to products, but less so with materials. This research suggests the possibility of including a more complete list of attributes in a database of products or materials that could act as a resource for designers.

Keywords: Industrial Design, Aesthetics, Perceptions

1. Introduction

A vocabulary exists for communicating many technical attributes of manufactured products: function, geometry, materials and processes can all be described in words that – at least to the technically informed – have precise meanings. Is there a similarly precise language to describe the attributes of industrial design – the aesthetic or perceived attributes – of products? We have examined this question, assembled a vocabulary to describe these attributes and devised experiments to establish the degree to which they can be held to have generally accepted meanings. The method and results of this analysis are presented here.

Why is this topic important? The majority of consumer products are technically mature in the sense that their functionality now evolves only slowly. Consumers, offered a choice of technically near-equivalent products, base their choice, to a large extent, on the industrial design. An ability of consumers, and designers, to discuss and communicate ideas about industrial design becomes as central as that of describing technical performance. This requires an accepted vocabulary to describe products and introduce new concepts of industrial design to those with a technical focus. Clarity in discussing industrial design can help

demystify the field for students of engineering and can stimulate communication between technical and industrial designers in industry.

1.1. Product Attributes.

Any product has a set of attributes by which it is characterised. If we say a hairdryer 'costs £18, weighs 400g and is made of plastic' almost everyone will comprehend what is meant. If we add 'it is made of injection-moulded polycarbonate' many – though not all – will understand. To those with an adequate technical background, these words have precise meaning, allowing accurate communication. A set of such words, used to describe attributes, can be thought of a set of *index lists*. A product is characterised by a set of words chosen from these lists and these index lists can be organised in a hierarchical structure, a tree structure. Thus, polycarbonate is a word from an index list of materials: injection moulding is one from an index list of processes.

Here, the proper choice of a set of *index words* for each list is the key to describing product aesthetics and perceptions. Good index words are general enough to capture a cluster of associations, but at the same time precise enough to carry well-defined meanings. For instance, describing the hairdryer as made of a 'material' is too general; it conveys nothing. Describing it as made of 'polymer' is more precise; the word polymer stands for a cluster of well-known and well-understood attributes (such as the material's thermal properties) that distinguish polymers from metals, glass or wood. Describing it as made of 'polycarbonate' is more precise still, but fewer people will know what it means. To go further and call it 'Dow grade 301, high impact fire-resistant PC' is too precise for any but the most specialised of audiences, but there are times in later stages of design where this detail is appropriate. And, a good tree structure allows this precision to be used by the designer, as appropriate.

Thus a balance must be struck, in seeking words to describe product attributes, between generality (with a loss of precision) and specificity (with an ability to communicate only to the initiated). In describing technical attributes, this balance is achieved by establishing an accepted and well-defined hierarchy of vocabulary. Thus, staying with materials as the example, we can think of a tree-like structure of descriptors. Generality is greatest at the root and the level of precision increases towards the top. Each index word, at a given level of the tree, has a cluster of associations attached to it that can be defined and have widely accepted meaning. Communication about materials uses these words; a cluster of associations attached to any one of them is conveyed when the word is used, or – if the word is imperfectly understood – its associations can be found in technical handbooks.

Is there a similar hierarchy of vocabulary for describing the industrial design aspects of products? The next sections describe our attempts to answer this question. First, we must consider other research that has attempted to answer a similar question.

1.2. A Review of the Literature.

Research exists that explores the aesthetics and perceived attributes of materials and products. Among these, a number are relevant to the present study. One example is that of Professor Pekka Harni and his students, of the University of Art and Design in Helsinki, who studies the sensory experiences and associations of objects using, as prototypes, 12 different styles: folklore, deluxe, kitsch, porno, toy, cartoon, sport, pseudo-eco, army, professional, space and 'white plastic' [1]. Each style was applied, as a project, to 5 products: a toaster, an iron, a hairdryer, a kitchen mixer and an electric shaver. The style was achieved through choice of material, of form and of surface finish. Luxury is suggested by the use of hardwoods, gold, silver, silk, leather and a conservative colour range; toys, by contrast, make extensive use of

plastics, have simple rounded shapes and primary colours. The findings indicate that links exists between the stylistic and symbolic attributes of products and the materials and surface treatments used to make them.

An earlier study, that of Ezio Manzini [2], illustrates how the combination of material and form is used to obtain specific product attributes (lightweight, heat resistance, elasticity, transparency and surface quality) and specific human responses – the perception, for instance, that a short bamboo stick is stiff when a long one seems flexible.

Directed at an audience of theatre stage designers, Faszination Licht [3] explores the use of light and colour in the theatre and particularly how colours can be used to manipulate the emotions of the audience. The author describes how colours are related to meaning, psychology, sound, taste and symbolic content: red, for example, has associations of power, dynamics, warmth, trumpets, sweetness and the erotic. Even though this is a highly subjective matter, light technicians are trained in these skills, and there exists a vocabulary in the field that has a sort of general consensus – a point relevant to the study described below.

Monö [4] describes how the aesthetics of design can be said to be the study of the effect of product gestalt (the physical appearance of the product as a whole including lines, surfaces, acoustic vibrations, olfactory substances, etc.) on human sensations. He also explains how the product can be perceived or interpreted in a broader perspective as a "meta" product including all the interpretations and ideas "behind" the physical product, such as prejudices, status, nostalgia, group affiliation etc.

Monö [4] and Søndergaard [5] explore product semiotics – the study of signs and their role in socio-cultural behaviour. A product transmits signs that are interpreted differently depending on the observer and the context. The authors use the terms *icon, index* and *symbol* as a basic vocabulary in describing the semiotics. An icon is an idealised abstraction of the attributes of a product (e.g. a frame for a painting), an index is connected to what it signifies by cause (e.g. tracks in the snow indicate that someone was here) and a symbol represents a recognition of agreement between people (e.g. a crown indicates royalty). This analysis also addresses the senses: for example, the sound of an angry voice can be a sign. The authors illustrate how meaning is built into a product; an entrance gate can exhibit both rejection or friendliness through the use of sturdy vertical posts and thick horizontal bars, or through curved shapes and decorative panels; an airline logo in fat italic letters signals power and speed.

Warell [6] works on developing a theoretical framework for describing the form design of products integrating technical and aesthetical issues. Like in a language a product can be seen as having a number of basic building blocks (form elements as an equivalent to the alphabet), a syntax (the arrangement of the ingredients) and a semantic structure (the meaning of the ingredients to an observer).

The work described above suggests that agreement can, to some degree, be reached in interpreting the emotions, associations, symbols and styles of products, and that these derive from form, structure, colour, surface and material.

We now return to our question of a vocabulary for aesthetics and perception. In exploring it, we have involved both industrial designers and behavioural psychologists. A number of general, and obvious, viewpoints emerge, but they should be stated. Attempting to quantify or structure aesthetic or perceived attributes is risky. Many of these attributes are subjective; they depend on the choice of material, the product itself, on the context and, importantly, on the culture in which the product is used. They are sometimes ambiguous, and their meaning changes with time: a product that appears 'aggressive' today can seem 'humorous' tomorrow; the use of translucent materials may be 'trendy' today but 'artificial' tomorrow. But then the

stock market, the economy, and above all the weather are subject to unpredictable change, yet we find it helpful to attempt to quantify and structure their attributes so that – at any point in time – they can be described in an intelligible way. Our aim, then, is to draw a map of the landscape of industrial design, even if it is changing, seeking the influences that materials and processes have in the aesthetics and perception of products.

2. Method

As an attempt at developing a vocabulary of aesthetic or perceived attributes and their connections to materials and products, we have chosen the following method: the formulation of an initial vocabulary, an experiment with design-course students (repeated twice), and a statistical analysis of the experimental data.

2.1. Formulation of a Vocabulary.

We have assembled index lists of words to describe the aesthetic and the perceived attributes of products; this list follows the structure of that shown in Figure 1. *Aesthetic attributes*, which we consider to be more specifically the 'sensory attributes', are those of colour, feel, form, etc. that each appeal directly to the senses. The *perceived attributes* include the following: 'symbolic attributes' are those characterising the associations carried by the product, 'stylistic attributes' establish its position in the history and development of design movements. To do this, we surveyed design-reviews of products in books, magazines and newspaper articles [7 – 14], noting the words used to characterise a product and its attributes. To these we added words used by museum curators to describe objects in design exhibitions and product descriptions from advertisements [15], giving the initial vocabulary list. The list was then simplified and reduced in length by replacing near-equivalent words with a single word (e.g. humourous ≈ funny; complicated ≈ intricate).

This survey led to the structure shown in Figure 1 and detailed in Table 1. The *sensory* attributes are straightforward. The *symbolic* attributes, probably the most important for this study, capture the associations carried by the product (each shown with an opposite to sharpen the meaning). The *stylistic* attributes link the product, when possible, to a design movement; these are good index words in the sense that they represent a cluster of ideas, but poor in the sense that they require prior knowledge of design history (an illustration of the challenges involved in practical indexing) and so were not used further in this study.

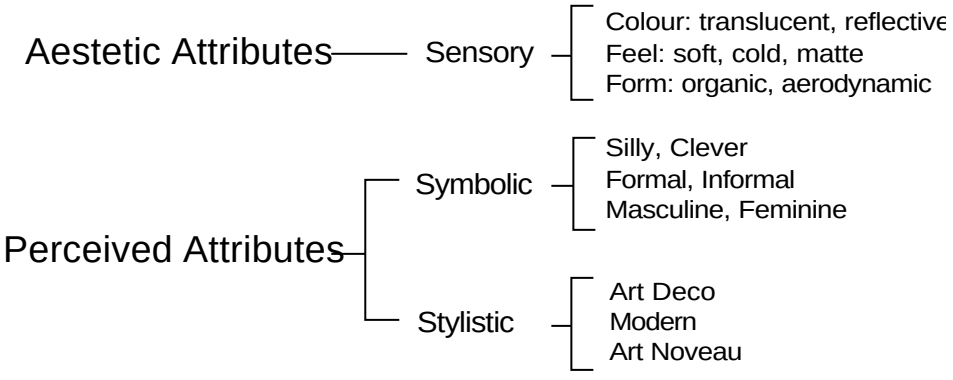

Figure 1. An abbreviated tree structure for aesthetic and perceived attributes. Each word carries a cluster of meanings, the most general on the left, the most specific on the right.

Aesthetics – **Sensory**	
Feel	Soft
	Hard
	Warm
	Cold
	Matte
	Textured
Form	Organic
	Angular
	Aerodynamic
	Industrial
Smell	Fresh
	Stale
	Natural
	Artificial
Colour	Transparent
	Translucent
	Opaque
	Reflective
Taste	Sweet
	Sour
	Salty
	Bitter
Sound	Muffled
	Ringing

Perception – **Symbolic**	
Aggressive	Passive
Cheap	Expensive
Classic	Trendy
Clean	Dirty
Clever	Silly
Common	Exclusive
Over-decorated	Minimal
Delicate	Rugged
Dull	Sexy
Elegant	Clumsy
Evil	Good
Feminine	Masculine
Formal	Informal
Friendly	Irritating
Functional	Useless
Futuristic	Historic
Handmade	Mass-produced
Honest	Deceptive
Humourous	Serious
Intricate	Plain
Mature	Youthful
Restrained	Extravagant
Temporary	Permanent
Weak	Strong

Perception – **Stylistic**
(1890) Art Nouveau
(1890) Arts and Crafts
(1900) Functional
(1900) Modernist
(1910) Futuristic
(1920) Art Deco
(1930) Streamform
(1945) Contemporary
(1960) Pop
(1960) Retro
(1970) Classic
(1970) Post-Modernist

Table 1. A vocabulary to describe aestetics and perception

2.2. The Experiment.

The experiment included participants from an Integrated Design Course run jointly by the Technical University of Denmark, the Danish Design School in Copenhagen and the Copenhagen Business School, and involved students from all schools working together in groups of three. As part of the course each group was required to redesign an existing product: an emergency tent, an insulin injection device, a laptop computer case and a children's board game. The experiment included three exercises. First, the students were asked to discuss, in their project groups, the aesthetics and perceptions of their products and the role of materials in each. Second, they were asked to describe, in their own words, the aesthetics and perception of six products with which they were not familiar: a toothbrush, a bottle of cleaner, a toaster, sunglasses, a sponge and a digital camera (Figure 2). Finally, the same groups were asked to re-examine the six products and choose words from the list of Table 1.

Figure 2. The six products used in the experiment

2.3. Analysis of the Data.

The last of the three exercises was structured to allow statistical analysis of the data. To do so, we make the null hypothesis that there is *no correlation* between the attributes of the six products and the words given in the list of Table 1. If this hypothesis is true, the distribution of responses can be calculated by standard statistical methods [16, 17]. If the real response-distribution differs from this, we can assess whether the difference is significant, and at what level.

The probability of an event A occurring r times in n trials, if successive events are not correlated, is given by the terms of a Binomial distribution:

$$p(r) = {}^{n}_{r}C.[p(A)]^{r}\,[p(\tilde{A})]^{(n-r)}$$

where $${}^{n}_{r}C = \frac{n!}{r!(n-r)!}$$

and $p(A)$ is the probability that the event will occur in a single trial

$p(\tilde{A})$ is the probability that the event will *not* occur in a single trial.

Given a choice of N words, the probability of one being chosen at random is

$$p(A) = \frac{1}{N}$$

and the choice that it will not be chosen is

$$p(\tilde{A}) = 1 - \frac{1}{N} = \frac{N-1}{N}$$

If the members of the test group make n attempts to assign a word to a product, the probability that a given word will be assigned r times to a given product (assuming no correlation between them) is

$$p(r) = \frac{n!}{r!(n-r)!}.\left[\frac{1}{N}\right]^{r}\left[\frac{N-1}{N}\right]^{(n-r)}$$

With this expression we can compute the probability of – say – 10 of the 14 members of the test group choosing the same word to describe a perceived attribute of a product. Figure 3a shows the distribution p(r) for Object 1. The most probable number of responses is near 4.

We are interested in the probability of a score exceeding some level r* above which it can be deemed to be *statistically significant*. The probability that an attribute gets a score of r greater than r* is

$$P(r^*) = 1 - \sum_{0}^{r^*} p(r)$$

This cumulative probability, for Object 1, is plotted in Figure 3b.

We must now assign a *significance level*. We adopt the severe criterion that the null hypothesis is disproved if the probability of the score is less than 1%. The probability of a

score greater than r* for Object 1 falls to a value below 0.01 at $r^* \geq 9$. Any words with a frequency greater than the significance level are significant with a 99% confidence limit.

We have applied the same procedure to each object, for both sensory and symbolic attributes, obtaining different values of the significance level for 99% confidence. In each case, a number of words emerge as characterising the aesthetic and perceived attributes of the object.

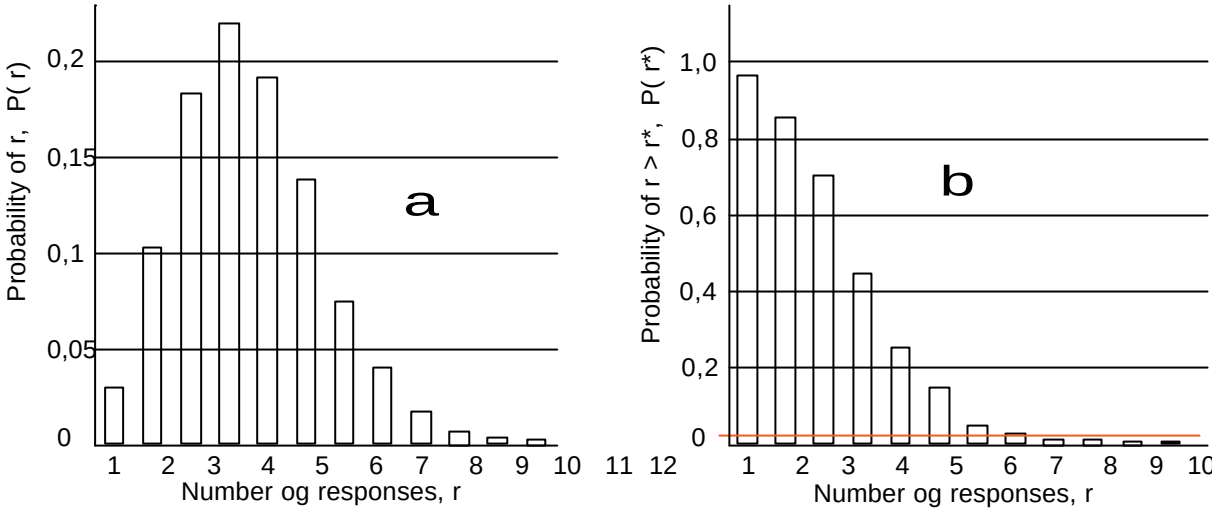

Figure 3. (a) The response-probability p(r) for perceived attributes and Object 1: Toothbrush. (b) The cumulative response-probality P(r*) for aesthetic attributes and Object 1.

3. Results

For all six products we find significant agreement in the use of certain words to describe the aesthetic and perceived attributes. The *Oral-B CrossAction* toothbrush feels soft, is seen as being organic in form, opaque in colour and muffled in sound; it is perceived as trendy, clean, functional (see Figure 4 where the cut-off is plotted as a vertical line.). The *Superdrug* toilet cleaners smell artificial and are opaque in colour; they are perceived as cheap, common, dull and mass-produced. The *Bosch-Siemens Premium Line* toaster feels hard and cold and has an aerodynamic form; it is perceived as aggressive, expensive, exclusive, masculine and futuristic. The *Oakley X-Metal Romeo* sunglasses feel hard and have an aerodynamic form; they are perceived as aggressive, expensive, trendy, clever, masculine, futuristic and youthful. The bath sponge feels soft, is organic in form and smells artificial; it is perceived as cheap, silly, feminine and mass-produced. The *Canon IXUS* digital camera feels hard and cold, is angular and industrial in form and has a reflective surface colour; it is perceived as expensive, clean, masculine, functional and strong.

The results of this experiment have also given insight into the completeness and effectiveness of the initial choice of vocabulary for aesthetics and perception. By considering the students' descriptions of each product without any bias from our own list, we discovered some words that were missing and some words that were slightly inappropriate. Additional attributes for texture and form – like smooth, rough, slippery, flat, squared, etc. – were added to our list; and the attributes of colour were expanded. The attributes of perception were reconsidered as well and some words were edited. One important feature of this new list is that no word has entirely negative implications and therefore could be desired for a given product. In addition, words like efficient and quality, which were often used to describe the products in this experiment, are not actually perceptions – they are simply attributes of good design and are therefore not included in this list. A revised language for aesthetics and perception is included in Figure 5.

For the majority of this paper we have discussed the aesthetic and perceived attributes of products, but one important question that is still unanswered is how these product attributes are influenced by choice of material. As was mentioned previously, each student group was asked to describe their product and how materials influenced the aesthetic and perceived attributes of that product. The students designing an emergency tent described the aesthetics of the current design, made of LDPE and polyester fabric, as rubbery, artificial in smell, translucent and coloured; the design was perceived as temporary, artificial and impersonal. They chose polymers with perfumed additives, polymer foams and natural fabrics for the re-design to create more warm and natural aesthetics and the perception of a personal, cozy space. The students designing a new insulin device described the aesthetics of the current design, made of polymer co-moulded with elastomer, as finely textured, rubbery and coloured; the same design was perceived as high-tech. Their re-design added steel parts to give the perception of durability and robustness – qualities they associated with the Volvo brandname. Materials have a very strong and consistent influence on aesthetics, but a less predictable influence on perception. The perceived attributes of a material can be altered by form and context, but the choice of material is an important starting point – it is this material that is manipulated by the designer in the creation of a product's function, use and delight.

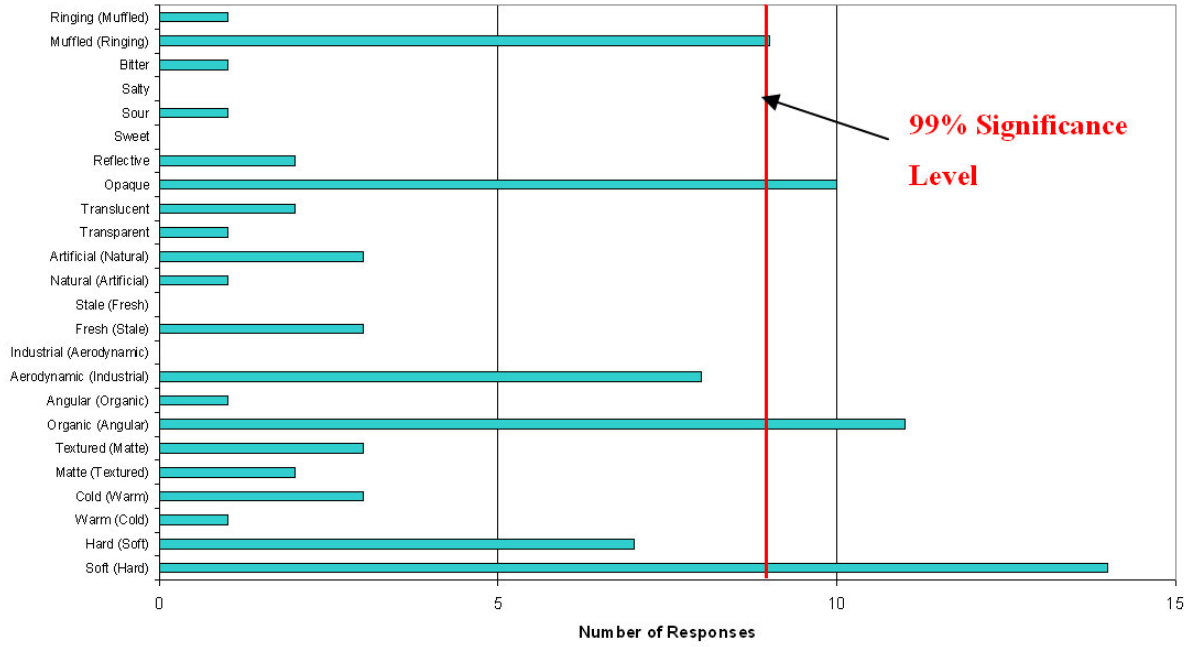

Figure 4. Results of analysis, *sensory* words selected - Object 1, the toothbrush.

4. Discussions

Markets are influenced by designs which combine, in an appropriately balanced way, the technical, aesthetic and perceived attributes. Technical attributes can be described in a vocabulary that allows general understanding. Communicating aesthetics or perception is more difficult, yet obviously important if designers are to transmit ideas between each other, within a company or to consumers.

Products certainly have attributes that we have called their aesthetic and perceived attributes. The nature of the materials used to make a product play a major role in creating these attributes. But can the *material itself* be said to possess them? Examples can be cited in which, it seems, they do. Material names appear as metaphors for perceptions in English and in other languages – iron woman, leaden conversation, mercurial character – implying the

perceived attributes that each represents. Cork can have associations of warmth and friendliness; steel, of strength and durability; wood of tradition; gold of wealth. But each of these, in another context (that is, incorporated in another product) could be perceived in another way: a steel drinkcan does not symbolise strength or durability; the use of gold connections on computer chips does not symbolise wealth.

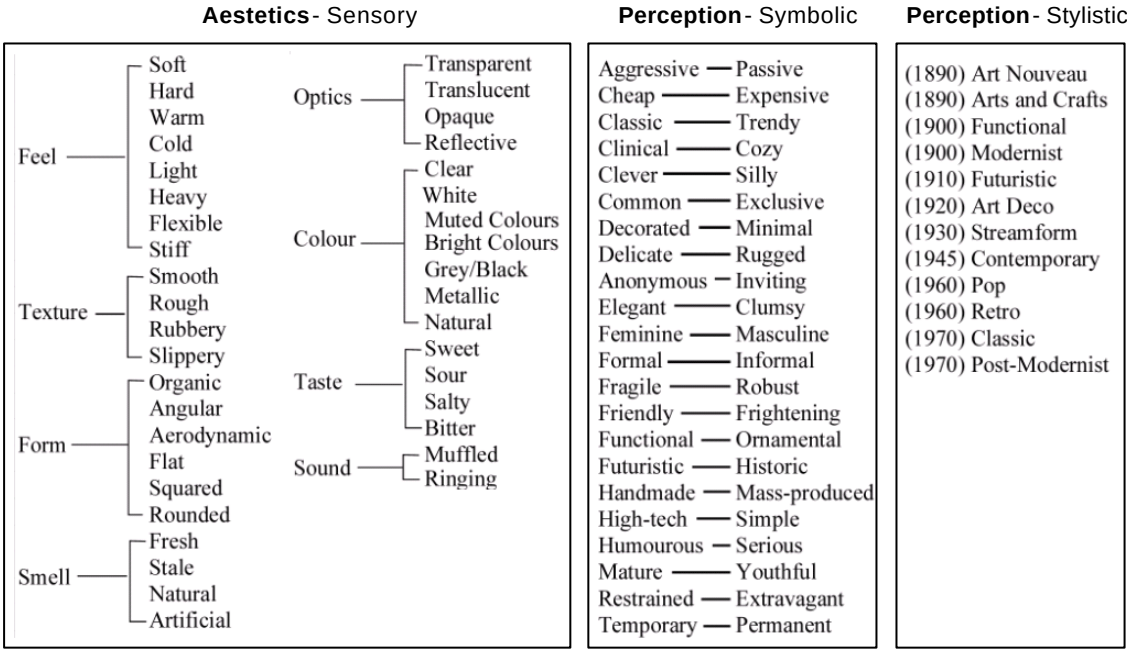

Figure 5. A revised vocabulary of aesthetics and perception

The results of this study suggest that the connection between materials and perception is at best a hazy one; that between materials and aesthetics is stronger. Colour, of course, is a characteristic of some materials – silver is silver, gold is gold, brass is yellow. But many materials – particularly plastics – can be coloured at will; in fact, they are rarely seen in their natural, uncoloured state. Texture is the same: some materials have a natural texture – wood, cork, sandstone, woven cloth – and some have an artificial texture: polyethylene, rubber and polymer foams are examples. But all materials can be coated and textured by surface processes, imparting to them attributes that are not intrinsic to the material itself. The participants in this study had no difficulty in assigning attributes of colour, texture and feel to a material when these were intrinsic, not achieved by some additional treatment.

Beyond the aesthetics, it was clear that while the perceived attributes of a product can often be associated with the material of which it is made, the material in isolation can only rarely be said to possess these attributes. For the most part, materials acquire their associations through the product in which they are incorporated. They contribute in an important way to creating the character of a product, and thus play a direct role in industrial design. It is useful to know what a product with given associations is made of – the knowledge can help the designer impart these associations to some new design. But the associations of the material itself cannot be strictly defined, becoming definite only when seen in the context of a product.

This report describes an initial investigation of a vocabulary for describing the aesthetic, the perceived and the role of materials in each. We have found success in linking (with statistical significance) aesthetic and perceived attributes to individual products. We recognise that the results reported here qualify at best as a preliminary survey. Definitive results await a more comprehensive study, examining a larger portfolio of products and soliciting responses from a wider group. The purpose of this paper is not, however, to present definitive results, but to describe an approach we believe to be novel, and to demonstrate that it allows meaningful

data to be gathered and significant conclusions to be drawn. Using this approach we have been able to show that certain index words convey a generally understood meaning, particularly when linked to products. A lexicon of these words, with examples of products and perhaps materials associated with each, could provide a useful resource for both industrial and technical designers.

Acknowledgements

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