# A Design-relevant Model for Product Analysis: Why the existent is not enough

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## Abstract

The present paper debates the need for specific methods for design research in one area, that of product analysis. Initially, on-going discussions on design research methods and product visualization are described. The relation of these to the debate at hand – namely on the possibility of visually assessing design differentiation in consumer products – is presented.

The paper is informed by literature on methods for visual and object analysis currently employed to investigate the shape design of products. There is a discussion on traditional models for artefact analysis when these are employed to compare groups of products. The discussion will highlight the shortcomings of these methods for understanding product shape differentiation and draw attention to their flaws when the aim is a comparative analysis of a three-dimensional sample group. The central argument is that knowledge on the product, gained when conventional artefact analysis methods are applied, is only tangentially relevant to design.

Finally, a new model for comparative product analysis is introduced. This model was developed to bypass the limitations of those methods in existence. The newly developed model is used to illustrate the possibility of combining various types of visual analysis methods in order to better understand the quantitative and qualitative information materialized in product design.

*Key words: Product analysis, shape differentiation, visualization, design analysis methodology, psychological experimentation.*

## Introduction

Design research has been built on the method and contextual paradigms that have been the traditions of a range of other research areas. This situation creates distinct issues and challenges for the researcher and the research community. Particularly in methods available for the visual analysis of product shape, it was sensed that the existing ones were not enough to provide information that was significant to design concerns.

Physical product differentiation is the design concern addressed by this investigation into product analysis methods. The central premise is that when designers make subtle physical alterations to products, as opposed to radical innovations, they run the risk of the product change not being evident or clearly noticed. In a variety of areas of product design, small style changes are now often used to provide greater choice and thereby stimulate more frequent shopping trips. It is therefore likely that a context in which differences between competing products are not noticeably visible would negatively impact sales.

A better understanding of what product features are seen under what conditions could help make shape differentiation more efficient and chances of a design difference being visibly evident, more predictable. The issue becomes one of accessing this design-relevant information contained in product shape in order to define what constitutes a visible design difference.

For the analysis of artefacts, there is a plethora of methods readily available. However it is our experience that, as *borrowed* investigative tools, these do not supply design-relevant information on consumer products. We felt a need for a new model that effectively considered products as design artefacts while focusing exclusively on their outward appearance. The newly developed model is used here to illustrate the combination of various types of analytical methods in order to better understand the quantitative and qualitative information materialized in product design.

## Current state of affairs

### A debate on design research methods

The idea that research in design lacks and needs specifically crafted methods is actively debated. In a more recent and visible debate[1], it was stated that a recurring subject in the creative design disciplines, is whether the academic design community uses established research methods from other disciplines, whether there are research methods that are specific to design, or whether researchers in this area should invent their own methods.

The above debate revolved around the central issue of whether there are design research methods that are unique to design. The discussions focused on the similarities between both the activity of research and that of design, as well as on the differences in nature and outcome of research in design as opposed to research in other disciplines. The consensus seems to be that academic design research makes use of a combination of established research methods from other disciplines, and of design methods ultimately embedded in these (Niedderer, 2004).

These methodological approaches are legitimate research routes and reflect many practitioner-come-researcher real case scenarios. However, the constant attempt at building new and more appropriate methods for investigating the produce of design, hints at the inadequacy and/or insufficiency of the existing methodology.

Illuminated by the above discussion, an unanswered question leaps to mind: In researching design, can we simply change the way in which established models and methods from other disciplines are used, or is it necessary to customize these methods and ultimately develop new ones in order to extract design-relevant information?

It is our contention that merely reviewing and tweaking existing methods is not enough to produce knowledge on and for design. David Sless has expressed the opinion that what is at the heart of research *"is coming up with a new type of ruler"* (Sless, 2004). We share this view and have considered, used and doctored several object analysis methods to suit our specific design-related needs. As a result of this experimental search, we propose in this paper a new model for comparative product analysis where we attempt to bypass the limitations found in conventional visual object analysis methods.

## A debate on the process of visualization

To analyse visually is human. Academic disciplines take advantage of our ability to orderly classify into categories (Bowker, 1999). Biological and chemical research, for example, have benefited from very clear and psychologically grounded levels of classification (Lakoff, 1987). Specific methods have been traditionally used to group and sort artefacts in the interest of museology, anthropology and archaeology.

Evidently the existing methods for visual analysis of objects are rigorous and time-honoured. The question here is not the value of these for use in product analysis, but rather of the possibility of visually assessing a consumer product.

Science works around the assumption that we see and then classify. Both the disciplines of cognitive science and visual perception agree that the mind envelops both processes analysing images formed, arguably, therein[2]. The design product as a sign may be divided roughly into material and semiotic dimensions. Both dimensions grant that products are visible images, have a very objective content and are displayed as three-dimensional representations (Petterson, 2001).

There is thus a divide between the concrete and the abstract qualities of products. This may reflect another divide – that of the visual process, between visualization as an experiential process and a mechanical one. Seen in this light, it is conceivable to split the act of seeing a product into distinct instances. Although eliciting various mental connections and personal meanings, the visual experience with the materialized product could be broken down and each visual process studied independently.

This sparks the debate between the semiotic and the cognitive view. The semiotic perspective regards visualization as strictly experience-bound. It is deemed impossible to disassociate form from content. This goes back to the very core of semiotic theory, where all that is, represents and signifies; there is no materialization without meaning (Vihma, 1995).

The cognitive position on segmentation of visualization is grounded on physiology and perception. According to Marr[3], our visual process is goal-oriented, therefore, depending on the task to be performed, different processes and equipment come into play:

*"A framework such as Marr's allows us to make sense of the functions played by the neurophysiologic machinery of vision, in terms of a more abstract description of the goals sub served by that machinery."* (Humphreys, 1989: 21)

Various visual processes are activated when we see an image – colour identification, motion perception, shape recognition. The early visual processing, groups edge segments and considers depth, i.e. the contour of objects, three-dimensional or other. The result is a viewpoint-dependent object description though the three procedures: perceptual classification, semantic classification and naming.

If we take visual cognition to accept the segmentation of visualization, we must establish where the partition would lie. Cognition considers levels of understanding in the process of acquiring knowledge. Once information is perceived – either actively or passively[4] – analysed and interpreted, it then comes to mean or represent something. The understanding of the object as meaningful would put it in the semiotic realm. The assumption made here is that prior to that understanding – where the product is seen, identified and classified – an investigation of the purely physical features could theoretically take place.

## Our debate

We regard visualization as a process involving roughly two aspects: seeing and interpreting. These two stages are separated by the experiential moment where we gain understanding of what is being observed. Following this rationale, it would be possible to divide visualization into more subjective and more objective considerations. Further experimental testing is required to elaborate on the experience of seeing and the mechanics involved in seeing. Nevertheless, the argument in this discussion is for visible differentiation and the search is for an adequate design analysis method to carry out the comparative evaluation of groups of products.

The study of visualization in this investigation focused primarily on checking whether – when we see differences in product shape – we classify or whether we scale visible design differences and whether or not *how* we see influences *what* we see. We understand classification to be a more subjective task, related to the experience of seeing thus responding to emotion[5]. Scaling is a more objective visualization process linked to the mechanics of seeing[6].

Conventional methods for artefact analysis conduct a visual interpretation, which essentially classifies based on physical similarity. The idea of classification comes from cognitive science and is successful when psychological levels coincide with material/physical/concrete levels, as in the case of basic-level categories for example.

On classification systems, Lily Diaz-Kommonen writes:

*"The mind selects the optimal option and treats items as equivalents when the differences are irrelevant to the human response."*
(Diaz-Kommonen, 2001: 4)

The value of this statement to our thesis is that, on a cognitive level, the mind classifies objects based on their visibly relevant differences. Classification systems are grounded on physiological regularities and are amiable to comparative visual analysis.

For the purpose of comparing groups of products according to visible design differences, certain limitations in this sort of analysis persist. The limitations are mainly caused by the personal interpretation conducted by the reader, making the resulting categorization imprecise. Pictorial representation of the artefacts also leads to inconsistencies in their treatment and angle of observation, which, added to the unavoidable fuzzy borders in each category, results in a high level of ambiguity in the overall classification.

These restrictions to conventional object analysis may seem pertinent only to the scientific approach, but it is essential that we deal with them if we are to approach a more objective and universal model for product analysis (Berlin, 1969).

Gunnel Pettersson describes products as signs discussing their semiotic level:

*"The scope of isolating the form from the content is to focus on the concrete descriptive visual information that can be observed independent of the work. This ability to abstract the three-dimensional visual structure that is inherent in all products, adds objective viewpoints to the creative process of shaping a form."*
(Pettersson, 2001: 6)

In other words, it is important to be objective and, apparently, semiotic writers could stand for isolating form from content in the name of enhanced objectivity. To quantify is perhaps the more objective of the analytical processes, immune to subjective interpretation so often in conventional object and visual analysis methods. In being objective, there is also the idea of an experience prior to emotion and subjectivity where we can try to define what we are *able* to see. One of the aims of the new model was to rank degrees of visualization so that the qualification becomes more meaningful, for it may sometimes be pointless to consider meaning in imperceptible differences.

There is also the idea of making object analysis more universal by using visual perception to analyze the sample. Typically, the design activity is aimed at and tries to impact the consumer or user. Humanistic approaches consider the individual; the marketing and design activity frequently look at niches and markets; the scientific approach in psychology may provide the physiological benchmark equating all as humans.

Again, the matter is what we are able to see in objects. This comes before the question of what we understand when we see them. The aim in the exercise is to discover if it is indeed possible to objectively measure what we can see. The possibility would mean a reduction of segmentation to one overriding class: humans over markets and individuals. This is obviously very ambitious but, presuming such universalism is shown to be possible would suggest the existence of more stable underpinnings to people's interaction with products.

The way Nelson Goodman refers to the process of purifying talk of images can be heard as a call for structured analytical methods of visual analysis:

*"What goes on is replacement of statements ostensibly about images by statements about objects and events. That cannot complacently be left until after the psychological investigations have been carried out in ordinary parlance; for our image-talk raw and unprocessed is a terrible tangle."* (Goodman, 1990: 362)

Like the terrible tangle he describes, our talk of shape perception without due quantification is also less useful.

## Methodology

In the study, methods proposed for product analysis, visual analysis, visual perception and psychophysics were considered. At first, generic object analysis seemed appropriate for the sought after comparative evaluation. However, the question of how to observe these products and how to measure and express the thesis of the small differentiation between their designs soon arose. Methods proposed for visual analysis were investigated to clarify the first doubt, then visual perception and psychophysics as means of quantifying and qualifying visualizations were studied to answer the second.

### Product Analysis

Literature on research into physical product features falls into three different areas: product properties, the design activity and the observer.

In the design literature, objects are commonly categorized according to either visual or functional properties (Riggins, 1995). Studies have tried to understand specific qualities, such as proportion (Lee, 2002), geometry (Birkhoff, 2003), form (Conolly, 2003) or function (Guyer, 2003) and their contribution to perceptions of products. This study will take a more holistic view of the product, investigating spontaneous visual reaction to its outward appearance.

Various attempts have been made at demystifying the intuitive process by which designers create. Attention has been given to the information (Chang, 2003), properties (Ding, 2001) and tools (Wiegers, 2002) necessary for optimal design results.

What is seen depends, to a certain degree, on the observer who has been studied as a consumer/user (Kano, 1984), a human being (Maslow, 1962) and an instrument of visualization (Coughlan, 1999). Here, if the observer is considered as a generic instrument of visualization, how much of the differentiation in one design compared to the next is visually perceptible? What design elements or features are responsible for the identification of alteration?

## Visual Analysis

To study articulated objects, composed of more than one design element, Gillian Rose (2001) suggests compositional interpretation, the *good eye* as she calls it. This type of analysis concentrates mainly on the compositional modality of the image and requires total attention to it. According to compositional analysis, some of the key components in an image are its content, colour, spatial organization, light and expressive content.

Rose goes on to suggest content analysis as appropriate in dealing with large samples in a systematic fashion, guaranteeing it is a qualitative, as well as a quantitative technique, which requires little reflection. Krippendorff (1980) expands on this method of analysis. From him we take the structure of content analysis and use the idea of sample and category definition, coding, interpretation and validation processes in the model development.

## Visual Perception

Visual perception aids in relating the visual object to the visualized one. As a consolidated discipline, various branches sprang from the German Gestalt School. All of these lines of inquiry tackled the study of human visual perception less as a speculative undertaking, more as a crucial demonstrative experiment.

Visual perception studies concentrate on the two-dimensional representation of, normally, tailored images, created to prove or test a hypothesis. Zusne (1970) is openly hesitant towards the Gestalt laws claiming that because these psychologists were preoccupied with the projected form and developed their principles on organization using two-dimensional shapes, their understanding of form perception is somewhat skewed.

An offspring of the Gestalt School, Rudolf Arnheim (1974) takes his instruction on visual perception to the field of fine and applied arts, relating them to the making and visualizing of the creative work. Much of what had already been defined using fictitious, fabricated visual stimuli, is by him demonstrated on real images and objects. Describing form, he calls attention to the most adequate angle, the view in which the three-dimensional object is most explicit, less violated by the flat representation.

Lengthy and detailed explanations of the Gestalt theory, its principles and experiments, have filled numerous volumes. What is central and to be considered here is the possibility behind the concept: formal quantification, the precise and countable ways of relating form and perception. This possibility is made clear and expanded on by J. J. Gibson (1950). In describing a visual world different from the visual field, he leads psychologists into the more comparative and relational physical territory of psychophysics.

## Psychophysics

Psychophysics is the attempt to find the physics of the body. It consists of applying a physical stimulus to a subject, and then getting the subject's report of the psychological experience associated with that physical stimulus (Lodge, 1981). One of the discoveries of this field is the notion of threshold – a psychological limit to perception. The absolute threshold is the lowest amount of sensation detectable by a sense organ. The relative or difference threshold is the lowest difference in sensation detectable.

Ernst Weber was the first to describe the difference threshold mathematically: $\Delta I / I = C$. Weber's law can be stated as follows: for any particular sensory system, the ratio of the difference in stimulation divided by the original stimulation is a constant. Different sensory systems have different constants. Gustav Fechner, working at the same university, but unaware of Weber, discovered the same law, but stated in an equivalent mathematical form. The answer of psychophysics to the psycho-physical relation is given in the generalizations known as *Weber's Law 1*, *Fechner's Law*, *Weber-Fechner Law* or the *psychophysical law*, all of which profess to formulate with exactitude the existent relations between change of stimulus and change of sensation.

Hundreds of experiments in psychophysics have shown that people can make very accurate proportional judgments about visual, auditory, and other sense stimuli. Modern psychophysical research has generally abandoned the Weber-Fechner law, and instead uses a *power law*. The most notorious Power Law is possibly Steven's (1957) derivation.

## The Proposed Model

Based on conventional methods of visual product analysis discussed above, an alternative model for Comparative Object Analysis was developed. The constructed model proposes an alternative method elaborating on physical properties of the objects investigated according to principles of visual perception and measured by psychophysics formulas. To test the value of a more objective and universal means of visually comparing groups of products, a Computer-based Assessment Tool was devised. This computer artefact is a structured test informed by the design of psychological experiments.

Studies closely related to the present project have used computer 3D morphing techniques to determine recognition and preference of kettle shape designs (Lin, 2003) and Weber's Law of Just Noticeable Differences (JND) to quantify the change necessary in a stimulus to produce a noticeable variation in sensory experience (USD, 2003). A merger is proposed: by using morphing tools, a form spectrum can be created of any type of product and a scale of visually perceptible differentiation can be established much in the way psychophysicists have done using JND.

The Computer-based Assessment Tool is composed of 4 tasks. Two tasks test for the same factor but through two different techniques. The two sets of tasks are also comparable in that each set tests a different aspect of the visualization process. In other words, the 4 tasks test for two different things and test two different processes.

Categorization is conducted in the first set of two tasks (Figure 1). The first task asks subjects to classify similar objects into groups and clusters (the visual process used for this task is classification) and the second task has subjects grade how similar pairs of objects are (differences are thus being scaled). This Multi-dimensional Scaling (Task 2) is then demonstrated as a classification system, the computer automatically clustering the objects based on the mark each was given. In other words, the visual process employed for each task is different but the reading is transferable, enabling a comparison of the results so that conclusions may be reached as to the difference in *what* we see depending on *how* we see.

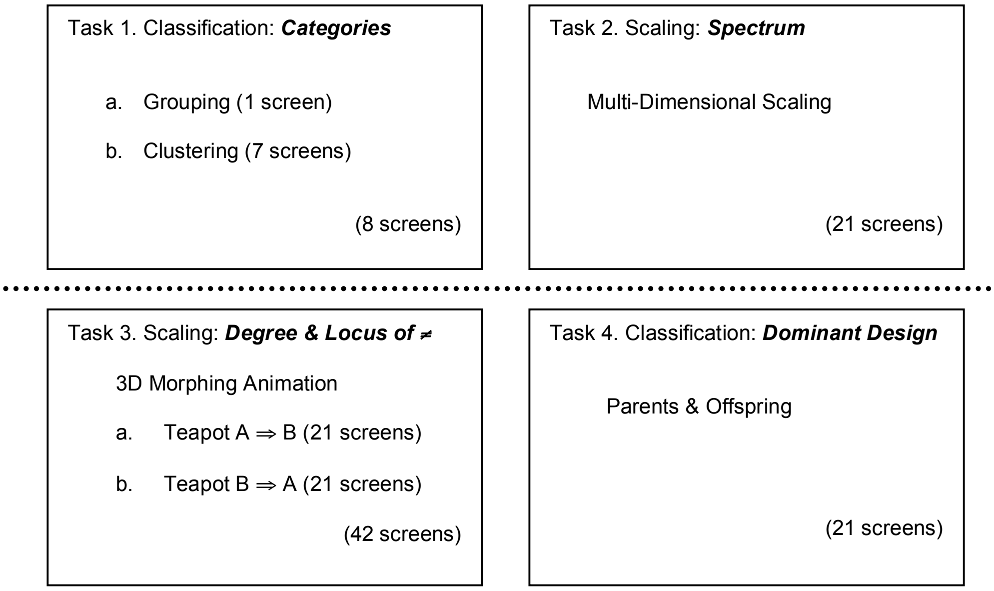


Figure 1: Diagram of Computer-based Assessment Tool tasks.

The second set of tasks (Figure 1, Tasks 3 & 4) looks for degrees of design differences and the design element responsible for the detection of change. The scaling capacity of visualization is tested in Task 3 when design differences are graded on how much change has elapsed from one to the other, through observation of morphing animations. This task also provides us with the design element or locus responsible for change in the design, for testers are asked to pinpoint the place on the object that triggered their detection of change. The second task of this second set, Task 4, tests for degrees of visible difference but in a comparative mode, where hybrid designs are classified as being offspring of one of two parents. Again, these two tasks test for the same thing – degrees of difference – but through two different visualization processes. The results of each task are expressed in percentage of transformation from one object to another, thus directly comparable.

Testing of the Computer-based Assessment Tool should answer the central question: “Do the experimental results vary when we visually analyse objects by classifying them as opposed to scaling them?”

The answer being "No" – the way in which design differences are analysed makes no difference to the quantity and quality of the seen differences themselves – presumes that using psychophysics principles is possible in visual product analysis. A holistic evaluation of product visualization would be possible through computer-based morphing, for example. It is therefore acceptable to scale visible design differences.

If the answer is "Yes" – when we classify, we see differences differently from when we scale them – means we have to consider the product as a whole, all its dimensions, both physical and abstract, when analysing it. This may be because all product features play a role in its visualization making this an extremely complex process, impossible to breakdown. Or still, knowing that our classification abilities require qualitative judgements, we could interpret this subjective process involved in visual analysis to override the more quantitative appraisal conducted in visual scaling.

It is obvious that we should be cautious when generalizing. Surely, there are a multitude of factors influencing and interfering in our visualization of design differentiation, of which the particularities of the visual system are but a few. Nevertheless, it is anticipated that through structured experimentation, conclusions are reached as to the value of running psychological tests with consumer products as stimuli.

## Concluding Remarks

The portion of the study discussed in this paper looked at traditional methods for visual and object analysis when applied to groups of products in a comparative exercise. The paper argued that the results from these, if left raw and unprocessed, do not supply design-relevant information. The new model for comparative product analysis created to bypass the limitations of those in existence, was presented. This model tests both conventional means of visual classification and categorization as well as visual scaling of visibly detectible design differences. Future discussion will compare the results and assess the benefit of one visual process over the other. The conclusion should show the value of visually analysing products confirming that visualization, as a registration process, is susceptible to being measured. The value of this is information with an increased relevance to and rapport with design.

The final outcome of the investigation is an evaluative model by which visual perception of product differentiation can be assessed. The model will make direct visual comparison possible and quantifiable based on principles of psychophysics.

There is a contribution of new knowledge to effective design differentiation techniques and to the comprehension of product appearance. The new knowledge resulting from this study benefits both academics and industrialists. Researchers in areas such as design theory, visual perception and material culture will be able to use the model for their own purposes. The findings fuel consumer testing in an industrial application. Both design and marketing professionals will benefit from clear concepts on visualization of differentiation when developing new products and strategies. The newfound information may also open industrialists to different ways of thinking about product differentiation and market research.

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## Biographical note

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1 The referred debate is available at PhD-Design@jiscmail.ac.uk on-line discussion list under the title “defining Design Research Methods”.

2 Nelson Goodman discusses the existence of a ‘mental image’. He debates whether or not what we see is indeed represented in the mind and, if these mental images hold any resemblance to the real object observed.

3 The British neurophysiologist David Marr described visual constructions by analogy to information processing in computers: ‘Vision is a process that produces from images of the external world a description that is useful to the viewer and not cluttered with irrelevant information…’ Marr thought of vision as an active process that produces useful descriptions.

4 No assumption is made here on the nature of perception, merely an acknowledgement of the different theories in existence, i.e. J. J. Gibson’s view of perception as the active pursuit of relevant information, where the agent seeks out from his surroundings that which should be noticed.

5 For a discussion on seeing as experience, see Hopkins. For the cognitive view on emotional reactions to design and levels of connection and response to consumer products, see Norman.

6 Scaling and measurement theories are used in disciplines linked to psychophysics and physiology where the human body as a perceptual system is frequently tested for its associative and standardizing capacity. Psychophysics will be discussed very briefly later in the text.