Chapter 6
Industrial Design

Thomas Gatzky

With the beginning of the mass production of goods of all kinds in the eighteenth and nineteenth centuries, new questions arose about their design. The artisanal production method, which was predominant for centuries, was characterised by a low degree of division of labour in design, engineering design, and execution (often in one person and in a very direct connection between designer, manufacturer, buyer and user). As industrialisation progressed, planning and production processes based on the division of labour developed and the relationship between planners and end customers became more anonymous.

One result of this development is the emergence of the profession of the industrial designer. At the interface of design and engineering design (in German: Konstruktion), it is his task to translate the cultural, social, and user-related design requirements into a contemporary design appearance. His special focus was directed towards the individual user of mass products in the context of social and economic interests.

For decades, the consideration of humans as users of products played a subordinate role in product development processes. Only when a modern education in industrial design became established and more and more companies understood design as an economic factor, can one speak of integrating industrial design into product development. Developments in art and culture of the twentieth century, especially the work of the Bauhaus in Dessau, changed the view on the design of mass products. The dynamics of economic processes and the emergence of the consumer society after the Second World War gave industrial design a firm place in the product development process. The field underwent further consolidation in the 1960s and 1970s through its integration into the development of capital goods and the inclusion of industrial design content in engineering studies.

Today industrial design is a natural part of interdisciplinary product development processes of consumer and investment goods. Industrial design as a training discipline

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and professional field of work is highly diversified according to the objects to be designed. The design of consumer and investment goods is described in this chapter under the term product design and described and stored within IDE with the attribute *Product Gestalt*[1].

Product design gives objects culture, identity and charisma. It is always an expression of values of the time in which it was created. In this respect, the human being is the yardstick of creative trade, not the technology. Product design develops product requirements such as sensuality and meaningfulness, because people in their role as buyers, owners and users expect product features that correspond to their individual ideas and possibilities.

However, the technical performance of the product alone is no longer sufficient to make it attractive to people, because it is the product design alone that makes products individually sensual to experience. Consequently, product design is a necessary component of the quality of a product. Good product design creates added value that pays off economically and contributes to the success of a company. For many companies, *good design* has become a distinctive mark. Scandinavian design, but also the label *Made in Germany* as a successful synthesis of technology and design, is part of an economic success and have changed the awareness for a new product culture worldwide.

In order to be able to meet these requirements, an intensive examination of *human-oriented product requirements* in the early phases of IDE is necessary. This approach is made possible and encouraged by the human-centred approach of IDE (Chap. 4).

In the design process, the industrial designer creates and materialises the entirety of all aesthetic relationships of use in a model-like manner. This is his core competence and his specific contribution to IDE.

User and product coalesce through the usage process an aesthetic relationship. The reciprocal effect of perception and behaviour as well as the quality of this effect determines the aesthetic utility value of a product. Accordingly, the aesthetic value of a product is not determined by the terms “beautiful” and “ugly”, but by the way in which the product is sensuous and/or meaningful.

Aesthetics always refers to the *human.* All questions of product perception, in particular, the design appearance, are connected with this.

So, what determines the *aesthetic value of* a product? Are there assessment criteria that describe good design?

Is Design for Perception the actual goal of aesthetic design [Gatz-2014], then *good design* is a value judgement in a broader sense. There are no binding standards for assessing the quality feature of *good design.* Rather, the standards are changing against the background of technical-economic, social and cultural changes in society.

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[1]Editor’s note: The English translation of the German term “Produktdesign” results in “product design”. However, the English term is not unambiguous as the German, because it covers different meanings like, e.g., “product development”, “product design”, “product layout”, “product draft”, etc. In order to avoid definitional ambiguities when talking about the first product attribute, the IDE term “Product Gestalt” (in German: Produktgestalt) is used throughout this book except of this chapter. Apart from this, the term “product design” used in this chapter corresponds fully to the term “Product Gestalt” used otherwise.

However, evaluation criteria have developed which have been widely used in professional circles and are used, for example, to evaluate products in design competitions and awards. Today, they determine the economic and cultural view of what is meant by *good design.*

In summary, ten value-relevant criteria for *good design* are explained. These also show how closely technical, ergonomic and aesthetic product features are interlinked.

1. High practical benefit: *Good design* combines high usability and perfect functioning of the product (IDE attributes usability and functionality).
2. High product safety: *Good design* means the implementation of technical safety standards required by the attribute safety, including a good feeling of safety, especially when using the product.
3. Very good product ergonomics: *Good design* involves adapting the product to the physical and psychological requirements of the user and his anthropometric conditions. Product ergonomics is a particularly important quality feature that is part of the IDE attribute Usability.
4. Long product life and validity: *Good design* is durable. Today, the congruence of technical and aesthetic durability is regarded as ideal. The demand for a long product life is a rejection of short-lived fashions and planned service life reductions (planned obsolescence [VDMA-24903]) through technical and aesthetic design measures. Long-life design is considered a special quality feature.
5. Technical and formal independence: *Good design* is independent, innovative and capable of being protected. Design protection (utility models, design patents, word and figurative marks) is intended to put a stop to the development of plagiarism. Plagiarism is never good design.
6. Ecology: *Good design* always includes aspects of sustainability. A special requirement is the perceptibility of these aspects in order to support a cultural change in the evaluation of new technologies, materials (waste, recycling) and product appearances (eco-design).
7. Relationship of product and environment: *Good design* is meaningful and appropriate in its product environment. The product environment is seen as the respective objective, social and cultural space. For example, the working environment, the urban environment and the individual living environment differ in their design requirements. The product design responds to the specific needs of the users of these different spaces.
8. Visualisation of use: *Good design* creates a shape of the product that informs about its function and use and that supports and facilitates handling. The design of the interface between user and product (interface design) is becoming increasingly important, especially for digital products.
9. High quality of design: *Good design* is product design that meets the needs of perception.
10. High product aesthetics as individually perceived sensual appeal: *Good design* promotes the perception and sensation of harmony, well-being and grace, but also of contrasts and tensions. It is a sensual stimulation as a prerequisite for an individual experience of use.

Criteria 9 and 10 refer in a narrower sense to the aesthetic requirements and design possibilities in product design. They are explained in detail in this chapter.

A large part of the criteria testifies to the integrative or holistic view of *good design* as part of product quality. Good design as a quality feature can only be planned and implemented in an interdisciplinary, i.e., integrative, manner. A well-functioning product with poor design is just as unacceptable as good design that envelops a poorly functioning product.

This chapter describes ways of looking at problems of product design with the aim to inform product developers about design issues in order to promote the understanding of the integrative working method within IDE. The better the understanding of the development partners for each other is developed and the necessary structural prerequisites exist, the more effective the product development processes are, which are a prerequisite for high product quality.

6.1 Product Development and Product Design

Product development is an interdisciplinary process. The implementation of constructive, technological, safety, ecological, ergonomic, aesthetic and economic requirements brings together the relevant specialist areas. From the point of view of industrial design, there are many interfaces and integration germs. Figure 6.1 shows the variety of interrelationships and references to other subject areas.

The independent proportion of the product values developed by product design in relation to the total values of a product should be briefly stated.

- Economy: Good design generates economic added value. Brand products achieve higher profits through their design.
- Safety: The implementation of technical safety standards also includes a feeling of safety conveyed by the design.

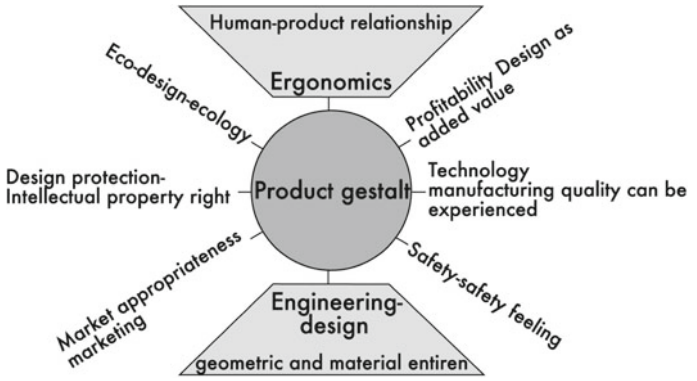

Fig. 6.1 Shape of the product as an interdisciplinary development goal

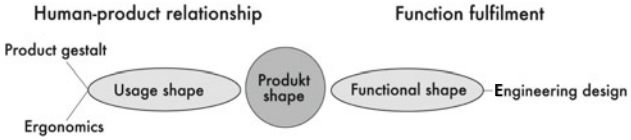

Fig. 6.2 Interdependencies of content and references of product design to other fields of expertise

- Marketing: Product design is an important marketing instrument. It creates distinctiveness, identity and uniqueness.
- Property rights: The protection of the product design ensures economic success.
- Technology: Manufacturing quality is demonstrated to the user by perfect surfaces and high-quality workmanship. High manufacturing quality conveys high product quality.
- Ergonomics: The ergonomic suitability of a product is inseparably linked to its design. Ergonomics and design refer to people in their role as users of products.
- Engineering design: The development of a technical form is closely related to the aesthetically based form, if the product has a distinct human-product interface.

Form and shape finding processes occupy a large space in product development and bring engineering design, ergonomics and product design as well as other areas (Fig. 2.2) closely together. From different perspectives and with different goals, engineers, ergonomists and industrial designers develop their ideas of form and design into a common development goal. The objectives and results pursued in this context show Fig. 6.2.

The shape of a product results from the fulfilment of its function and the objectification of the human-product relationships. Two design phenomena represent the process of form development.

- *Functional shape*: Formative criteria depend on the degree of fulfilment of technical-functional and economic requirements. Criteria such as load, material and manufacturing suitability are directly formative. In this context, a resulting geometric-material entity of a component, an assembly or an entire product is to be referred to as functional design.
- *Usage shape*: Formative criteria largely relate to the future use process by a user or user group. Aesthetic and ergonomic criteria are taken as a basis for the formation of a geometric-material whole.

The design of functional and utility shape is the prerequisite for the interdisciplinary development of a product design. The special relationship between engineering design, ergonomics and product design is determined by the common goal, the development of a geometric-material entireness of a product. Methodical procedures in design, conceptualisation and detailing phases, the use of analogue and digital design tools as well as structural-organisational relationships support the special relationship to each other. In the following, both interfaces will therefore be described in more detail from the point of view of cooperation.

6.1.1 Product Design and Engineering Design

Industrial designers and engineering designers are form designers! Both disciplines are united by the goal of jointly contributing to the development of the *objectivity of* a product. Both disciplines bear the main responsibility for the creation of a geometric-material whole of a product. Design and technological requirements such as load-bearing, material and manufacturing requirements (Chap. 9) are directly reflected in the geometry of components, assemblies and integrated products.

The design and creation of the geometric-material whole according to technical *and* aesthetic product requirements combine both fields of expertise, but are also fraught with problems. The common development goal *product* is being worked on from two very different perspectives. Different subject-specific goals, procedures, development methods and design tools have led to a pronounced *division of labour* in the early phases of product development. A different approach to product design and engineering design, which can be justified in terms of content, has often led and still leads to communication problems in practice. The temporal integration of creative activities, problems of communication and understanding, but also questions of organisational and structural linkage play a role.

Figure 6.3 shows the basic problem. It consists of the fact that in product design, a design appearance or a geometric-material whole is developed in the early design phases. This is the only way to analyse, evaluate and further develop the overall effect of a design concept. At this point in time, there are usually no design concepts for the overall appearance (structural design, housing). The coordination of product design (industrial design) and component design (engineering design) then becomes a problem with a lot of conflict potential.

Overall, the potential for conflict results mainly from the following circumstances:

- Increasing division of labour in the design processes, starting with industrialisation to this day
- Design methodological developments attached little importance to humans as users of technical products and therefore did not adequately reflect human-related product requirements

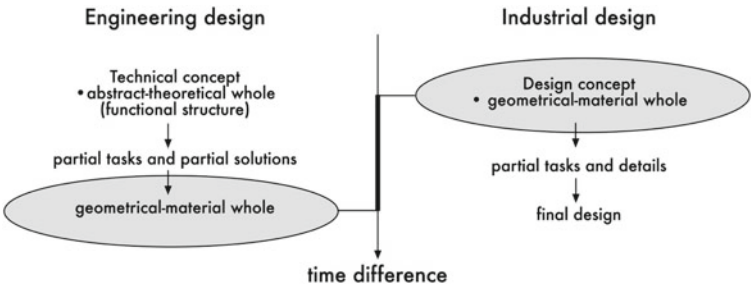

Fig. 6.3 Different time of the production of a geometrical-material entity [Gatz-2013]

- Development of design tools is strictly based on the division of labour.
- An engineering education follows the model of division of labour and thus attaches little importance to user relevance (human-machine interface), as well as an education of engineering designers and industrial designers "sealed off" from each other.
- An education of engineers and industrial designers "sealed off" from each other.

Even today, the classical engineering education is still composed of a multitude of teaching areas that operate without a view of an overall solution (overall design). In civil engineering, architecture assumes the role of the "design developer". The architect creates the design vision. Industrial design can and should play this role in engineering education. The different approaches to engineering design and industrial design are perceived as "normal" when they are explained in the training of engineers and designers, i.e., in terms of their tasks. A foundation laid in this way, as described in [NaGV-2004] and [Gatz-2008], creates the insight and willingness for an integrative approach in all design phases.

In practice, the problem has long been recognised. The development of a design vision, often in the form of a finish model of the future product, is increasingly becoming an important strategic and methodological instrument of development philosophy.

Designers and industrial designers, who both only know the procedures of "their" methods, are "at risk of conflict". Costly coordination and time losses occur when this difference is not recognised or accepted.

A number of possibilities can help to harmonise the relationship between engineering design and industrial design in the early stages of product development.

- Understanding and information about education and qualification in the respective field
- Parallelisation of the development steps with many iterations
- Integrative development environment (forms of organisation, structural assignments, communication)
- Common database and good interface design between the digital tools (CAD, CAID, RP, model making).

Procedures and methods of IDE accept the time lag and describe a development environment that is conducive to the collaboration of engineers and industrial designers within the holistic approach of product development within IDE.

6.1.2 Aesthetics and Ergonomics

Aesthetic *and* ergonomic product requirements refer to people in their role as users, buyers and owners of products. The concentration on product features and characteristics that relate to humans as biological and social beings has historically brought the fields of ergonomics (work science) and industrial design closer together.

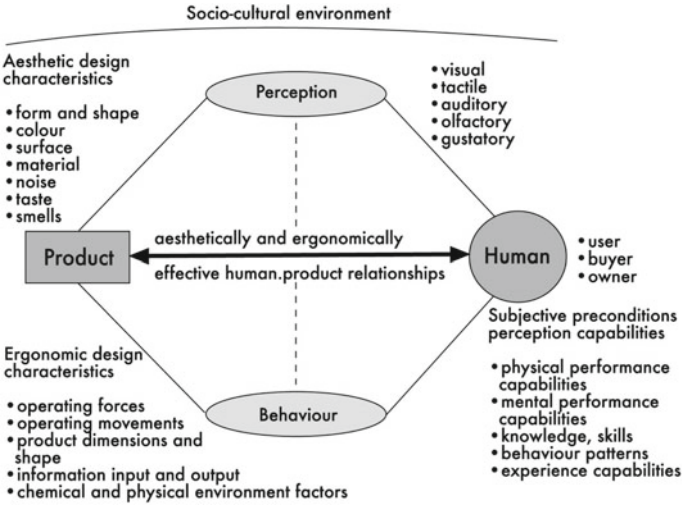

Fig. 6.4 Aesthetically and ergonomically effective human-product relationships [Gatz-2013]

The totality of all human-related product requirements bears aesthetic *and* ergonomic design features, Fig. 6.4. Therefore, in this context, the close and mutual penetration of *aesthetics* and *ergonomics* must be pointed out. The design of a chair is determined by ergonomic criteria, such as a fatigue-free posture. The geometry to be selected for this purpose also determines the aesthetic appearance of the design to be evaluated. The user expects these aspects to be combined in the sense of a holistic product design. In training and practice, however, industrial design and ergonomics are treated as separate fields of expertise, and accordingly, they are divided into two parts. IDE also provides a suitable development method for interdisciplinary and integrated design activities in both fields.

The reciprocal relationship of *perception* and *behaviour* which is a *usage process* combines aesthetic, ergonomic and perceptual psychological aspects of analysis and design.

SCHÜRER referred to the reciprocity of ergonomics and design. "In this sense, ergonomics is to be understood as a component of design and aesthetics as a component of ergonomics. However, this aesthetic is not to be understood as an associative, as a *pleasing aesthetic* but rather as an aesthetic that is related to the course of action and guides the action. On the one hand, it influences the experience of an object, and on the other hand, it influences the behaviour towards these phenomena, and finally, the action is related to them or to be carried out with them. Experience, behaviour and action are basic human dispositions. They cannot be met solely by properly trained elements for action execution, i.e., hardware-ergonomic. Rather, they are essentially influenced by the obvious, i.e., software-ergonomic training of action-guiding elements" [Schü-1988].

The design examination of usage processes also offers an opportunity to overcome the separation of design and ergonomics.

6.2 From the Idea to the Shape of the Product

In the development of a product, the creation of its geometric-material wholeness is the main focus of in the centre. Several engineering disciplines and industrial design make their own specific contribution. Depending on the profession and perspective, a geometric-material whole can mean a component form, an assembly form and its form and design appearance. The engineer and the industrial designer pursue goals that are directed towards the implementation of technical-economic and human-centric requirements.

The creation of a geometrical-material entireness of a product unites engineers and industrial designers. What is common and interdisciplinary is manifested very concretely in form and design finding processes, which make up a large part of the product development process.

Form and shape as technical *and* aesthetic categories and design objects are therefore the focus of the following explanations.

Designing means arranging! If the product developer recognises, the goal of arranging design measures within the framework of form and design finding processes, and if he understands how design *order* can be achieved, he will be open to the decisions of the industrial designer. Even for the design of the shape during engineering design, findings and design recommendations can be derived which support and accommodate the design intentions in product design. For this reason, the recognition of the *aesthetic design problem* in form and shape finding is *the* decisive prerequisite for a cooperative and integrative approach of engineers and industrial designers in the development of products.

Colour, material and surface aesthetic design aspects are indispensable for the development of the product design, but are deliberately excluded in the context of these considerations (for further information see [Seeg-2005]).

Designing, engineering and shaping are processes in which an immaterial state is advanced to a geometric-material state over many development steps. Descriptions of ideas, first sketches, abstract functional and usage structures describe the future characteristics of the product, but cannot yet be experienced sensually. From this, the first form and design concepts develop, which become more and more complete, holistic and perceptible in the development process. The advancing *specification of form and shape* is particularly driven by constructive, ergonomic and design objectives.

The development of a geometrical-material wholeness of a product is usually carried out as shown in Fig. 6.5.

The transition from immateriality to the geometric-material description of form and shape is also a transition from immaterial abstraction to perceptibility.

The shape of the product is thus determined from the point of view of the *human-product relationships* which are always part of the overall (technical, manufacturing,

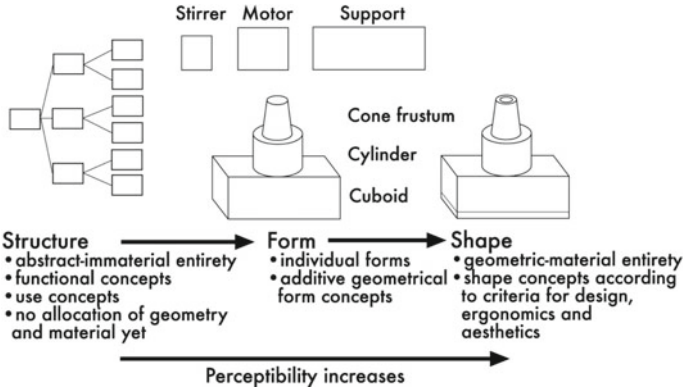

Fig. 6.5 Transition from the state of structure via the form to shape [Gatz-2013]

economic, etc.) product requirements. The shape combines the elements and their arrangement characteristics that enable the product to be perceived.

The stimuli required for sensual perception (aesthetics) are perceived via the *form*, the *colour*, the *material* and the *surface*.

The shape of the product is, however, not only the sum of the *design elements* but results from the elements and their relations (quantities and qualities) to each other. The relationships are called *shape structure*.

The attribute "Product Gestalt" describes the perception to be created as well as the perception of the prerequisites composed of the design elements form, colour, material and surface and the design structure in order to enable the use of a product in the sense of a perceptive human-product relationship.

From now on, concepts of form and design can be experienced by the senses and are therefore also subject to aesthetic analysis and evaluation. Interestingly, it is not only the constantly evolving shape of the product that can be sensually experienced, but also its representation in the form of design representations, engineering design drawings and representational models. Visualisation techniques for the early phases of a product development aim at an ever better perceptibility of design results.

6.3 Human-Product Relationships or the Basic Aesthetic Problem

In the traditional classical concept of art until the nineteenth century, *aesthetics* (Greek aesthesis: perception) is often equated with the doctrine of beauty. The focus of aesthetic considerations was on works of painting, sculpture, music, theatre and literature. Everyday products have traditionally not been evaluated according to the criteria of classical aesthetics. Reform movements of various kinds, however, brought *normal life* increasingly into the focus of aesthetic considerations. *The new unity of*

art and technology, propagated at the Bauhaus in Dessau, led to a new view on industrially manufactured products.

The concept of beauty has been extended to industrially manufactured products. This required a new aesthetic approach. Aesthetics has now been defined as the theory and philosophy of sensory perception in art, design, philosophy and science.

Accordingly, the *aesthetic value* is not determined by the terms "beautiful" and "ugly", but by *sensuality* and/or *meaningfulness* of the product. Aesthetics therefore always refers to the human being. All questions of product perception, in particular the design appearance and all acts of use, are connected with this.

Products are recognised by means of sensory organs (receptors). This creates perception stimuli on the product side such as shapes, colours, materials and surfaces. The processing of the stimuli leads to *behavioural reactions* which the human being perceives as an *experience*, *Action* and *evaluation*, Fig. 6.6.

But perception also means recognising content and meaning.

Behaviour can be described as the human reaction to what is perceived. Observing or actuating is important actions. They can also be perceived as an experience. Experiences and actions cause the user to judgements and evaluations. Devotion or rejection and verbal judgments such as "do I like or dislike" often conclude a human-product relationship.

The degree of fulfilment of a human-product relationship always depends on the interrelation of perception and behaviour. It makes sense, then, to postulate *design for perception* as a design goal. For the design process, meeting the goal of design for perception means dealing with perceptual stimuli. An example of this is finding the shape of a product that meets not only technical but also aesthetic criteria. Perceptually appropriate design means taking into account requirements that arise from the physiology and psychology of the human perception process (Chap. 4) and the individual or the experiences of the individual influenced by the respective environment and which are used to design products with regard to their design appearance.

Design for perception as a design goal and requirement means making products meaningful.

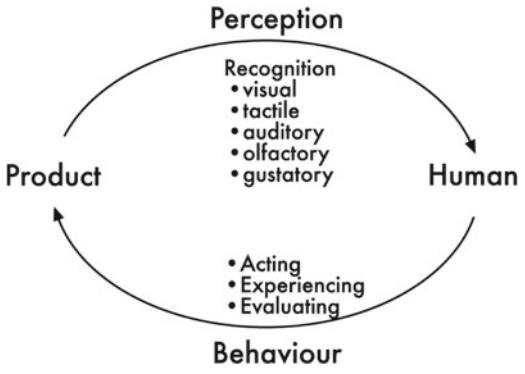

Fig. 6.6 Human-product relationship as a basic aesthetic problem [Gatz-2013]

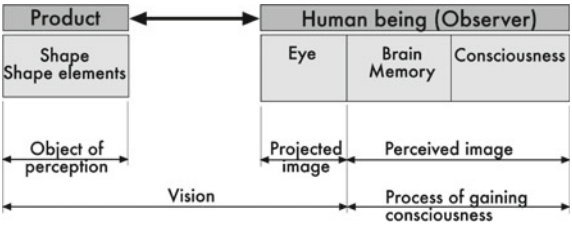

Fig. 6.7 Human-product relationship as a problem of perception [Gatz-2013]

6.3.1 Perception

Perception means seeing and becoming aware.

About 60–80% of all environmental stimuli are perceived visually. The *visual* thus plays an overriding role in human-product relationships and also explains the dominance of visual design aspects in product design. Figure 6.7 shows the basic relationships.

The human in his role as observer recognises the product. The prerequisite for this is the *shape of the product* and its *shape elements*. They are created in the visual process via the eye as a projection image. This is followed by a process of awareness, which leads to an individual image of perception.

So, there are two phases of *perception* to be differentiated:

Phase 1: The formation of a projection image is an objective, physical-chemical process that is developed in the same way in almost all people.
Phase 2: The formation of a perceptual image is a subjective process that depends on the individual memory content, experiences and values of the observer. The subjectivity of the viewer is co-determined by a socio-cultural framework that defines in particular values and norms.

In contrast to "objective" technology, product design has a *subjective aspect* as well. The user perceives and behaves subjectively. This poses a particular problem. Product design is part of a product development process for the creation of mass products that meet the needs of large groups of buyers or users, but where these groups always consist of individuals. It is therefore a particular challenge to develop mass products that can meet individual needs (i.e., leading to mass customisation). This is the reason for the intensive examination of user requirements in the product development process!

6.3.2 Perception, Behaviour and Usage

People *use* products to organise their lives and satisfy their needs. It is obvious that the design quality of the products has a decisive influence on the quality of life and meaningfulness. *Usage* or usage processes determine the active relationship between

man and product. In product design, a particular focus of the design and creation work is therefore on the development of *usage processes* of a future object in thought and material terms and to objectify it as a model, Fig. 6.8.

The usage process makes the relationship between perception and behaviour transparent. The object *sends* out perceptual stimuli that the human receives and processes. This is followed by a behavioural reaction, sometimes as a haptic action (pressing a control button) or only as unconscious emotion (turning), often combined with an evaluation (verbal judgement). Figure 6.9 shows a typical everyday situation.

A woman cyclist notices a passing car. She recognises a car because the archetypal shape of a car is stored in her memory. But she also perceives individual design elements. She consciously (information) and/or unconsciously (impression) interprets the design appearance that she perceives and reacts in many different ways. It can be an active action, e.g., a change of direction, but it can also be a passive observation. In any case, the perception of objectively existing design features leads to a behavioural reaction, which in turn depends on the design situation.

Starting from Fig. 6.9, the question now arises of how a usage process can be described in more detail. What does it mean to *use* a product? The aim of this

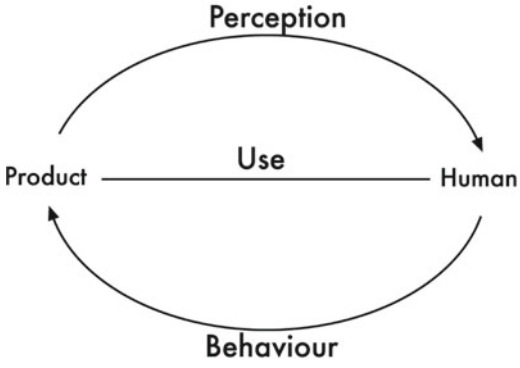

Fig. 6.8 General context of perception, behaviour and use [Gatz-2013]

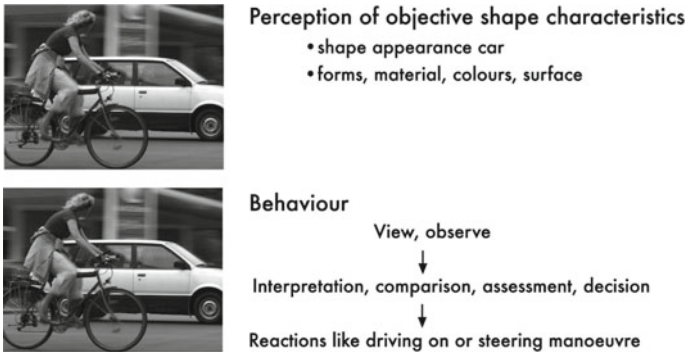

Fig. 6.9 Example of the relationship between perception and behaviour

examination should be to show design fields and to analyse all requirements that allow an assessment of the degree of fulfilment with regard to use and fairness of perception.

The use takes place on two levels, the level of perception and the level of behaviour. However, the process of use is also influenced by perceptual stimuli that people can consciously (information) and unconsciously (impression) recognise and experience as information and impression properties of the shape of a product, Fig. 6.10.

In the design process, information and gracefulness characteristics are developed. They can inform the future user of a product about certain facts and address his feelings and sensations.

A *design appearance* can provide information that can inform the user about different contents. For example, the user receives information about the design of the product or about form elements for purpose, function, use, value and much more.

The brush shown in Fig. 6.11 is a good example of the simultaneous clash of design and ergonomic intentions. The recessed grip on a brush is at the same time an ergonomic shape to allow good power transmission from the hand to the brush.

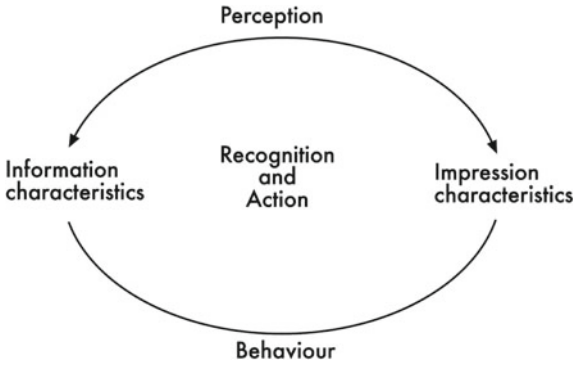

Fig. 6.10 Information and appearance properties in the use process [Gatz-2013]

Fig. 6.11 Brush with recessed grip

On the other hand, the trough is also a visual information that informs the user about the correct use of the brush. The correct recognition of this information can increase the feeling of security in the use process. Clarity, unambiguity, truth and easy accessibility are therefore quality features of good design. *Good design* should be self-explanatory, which means nothing else than that the design informs the user directly about usage properties and other facts.

The situation is different with the design characteristic of impression. *Impression* is the term for an unconsciously triggered emotion through perception. Product impressions address the subconscious and express themselves in *sensations*, *impulses* and *effects*.

Here are some examples of gracefulness qualities:

- Sensation: Feeling of well-being or discomfort, feeling of security or insecurity, feeling of prestige or inferiority
- Effects: large—small, fast—slow, harmonic—inharmonic, heavy—light
- Impulse: Stimulate spontaneous activities, e.g., touching (grip shapes, material surfaces), using, playing, etc.

As a quality feature or design goal, the accordance between objective design features and subjectively perceived expectations must be recorded.

Two examples are intended to make a correct and a wrong product impression understandable, Fig. 6.12.

Using the example of a wristwatch, design requirements that are related to perceptual correctness will be analysed. This leads to design requirements for a watch, for example, which enable or support recognition and operation, Fig. 6.13.

In this example, perception means to seeing a watch and to perceiving many things, among others:

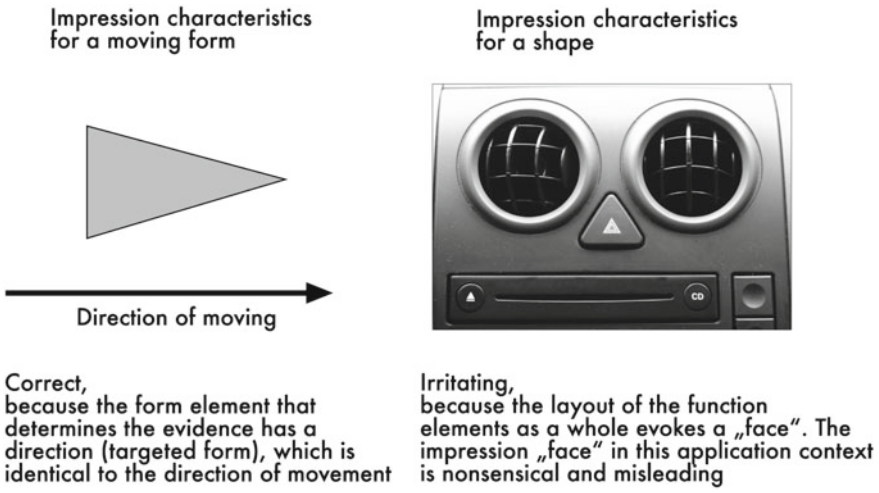

Fig. 6.12 Correct and irritating product appearance [Gatz-2013]

Fig. 6.13 Example: Using a wristwatch (photos from the Manufactum catalogue, 2009) [Gatz-2013]

- The shape has an archetypal form, corresponds to the cultural context and is therefore assigned to the product group watch and recognised as such.
- Recognition of purpose and function, modes of use as well as materials and processing quality and
- Conveying values.

Possible types of behaviour:

- Reading the time,
- In take the hand and wear it on the wrist and
- User actions such as winding up, setting the time.

The example is intended to make us aware that the relationships between people and products (user and watch) are determined by aspects of perception and behaviour and that the quality of these relationships can be consciously influenced by design in the design process.

6.4 Design for Perception as a Design Task

The design task in industrial design can be seen as the creation of a state of a proper design for perception.

By means of designing and model-like objectification, immaterial ideas (thoughts, ideas) are made sensually tangible through drawings and physical models. This also allows the following basic statement to be made for the design process.

When designing products according to aesthetic criteria, it is all about perceiving and feeling harmony, well-being and grace, but also about contrasts and tensions. The user experiences a sensual stimulation during the use process, which he perceives as an individual experience.

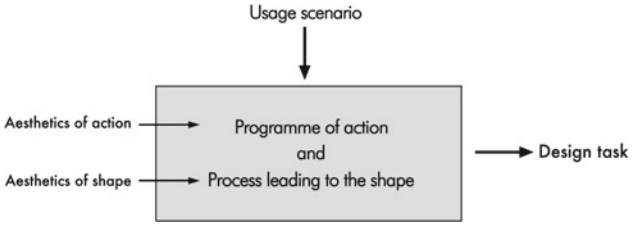

Fig. 6.14 Usage scenario as a design task [Gatz-2013]

The "dimensioning" of sensual stimulation is a crucial design problem. It is determined by the interrelation between perception and behaviour. In the design process, design measures are used to develop and simulate the future behaviour and experience of an individual user when using a product.

6.4.1 The Usage Scenario

At the beginning of every design process, there are questions such as:

- How should the future (and intended) user handle the product?
- What shape should the product to be designed have?
- Which action and operating procedures are correct or appropriate?

These and similar questions lead to design tasks that determine the future *usage scenario*. The usage scenario is determined by the entirety of aesthetic requirements in terms of action and design (Fig. 6.14).

6.4.2 Aesthetics of Action

Actuation and use operations are part of the product perception, and the actuation behaviour is experienced and assessed by the user. The quality of these operations often determines the value of a product.

Aesthetics of action is the sensual and meaningful component of user-oriented design. In the sense of a perceptual design, it deals with the management, inclusion and development of action situations of objective action. The criteria that can be shaped and evaluated are, in particular, action competence and control.

Perceptual design is characterised by the following principles, which explain the relationship between *perception* and *behaviour* reflect this.

- Principle of *simplicity*: The effort and benefit are in the right ratio. The correct appropriateness of design expenditure (design appearance) in relation to the purpose, the utility value and the value in itself is one of the most important quality

criteria. Simplicity appears honest, authentic, clear and orderly. Complexity (or overload) is often confusing, disorienting and inappropriate.

- Principle of *unambiguity*: Quick and clear recognition of a design situation leads to controlled and safe action operations.
- Principle of *visibility*: Well perceivable "signals" (information) are the prerequisite for safe action. For example, a coffee cup should have a sufficiently large handle. Not only so that particularly large fingers fit into it, but above all because of the recognisability of the usage function. The absence of these signals can lead to irritation and wrong actions.
- Principle of *feedback*: Both important action signals and their feedback must be perceptible, best visible. Feedback should appear immediately after the action. If they fail to appear or arrive too late, the user does not know whether the action was correct and successfully completed.
- Principle of *mapping*: Mapping refers to the meaningfulness of the representation of a functionality in the context of action and its result. The visualisation of function, action and real execution makes it easier for the user to recognise connections. Analogies and compatibilities to known experience values support the user in operating actions. A well-known example is the "trash" function on the user interface of a computer (the so-called "desktop"). The design is based on the design and organisation of a natural office. The "dispose" function is conveyed via the image of a wastebasket. The virtual disposal, insertion and retrieval is realised in analogy to the waste paper basket from the real world. Although data on the computer is disposed of differently than normal garbage, the user is familiar with the usage process via a pictorially represented but virtual wastebasket.

Particularly with electronic products and software interfaces (interface design), the design quality of action aesthetics is of paramount importance, since the use process is almost exclusively realised and experienced via an *interface* to be used. Action-aesthetic solutions are based on ergonomic, psychological and design knowledge. The cooperation of industrial designers, ergonomists and psychologists proves to be advantageous for the solution of action-aesthetic problems.

6.4.3 Gestalt Aesthetics

Perceptual design always aims at finding a design in its unity of form, colour, material and surface.

Since the geometrical-material wholeness is also and especially determined by technical product requirements, the design process results in manifold relationships to engineering design and technology.

Finding and creating a perceptual shape take up a large part of the design process. In the following, therefore, the basics of form and design aesthetic contexts will be described.

6.5 Introduction to a Perception-Oriented Theory of Form and Shape

The task of the *theory of form and shape* is to understand the recognition and application of objectively acting criteria in order to create form and shape and to be able to judge them according to appropriate criteria. In engineering, mathematical/geometrical descriptions are generally valid due to technical requirements such as load, function fulfilment and‘ manufacture. In product design, it is a matter of formal-aesthetic or perceptual descriptions based on aesthetic requirements.

A perception-oriented theory of form and shape can support the recognition and shaping of effects on humans under the aspect of the way in which form and shape is perceived.

6.5.1 Fundamentals of the Perception of Form and Shape

The most elementary way of perception is the *figure-ground relationship*, Fig. 6.15.

The contour in Fig. 6.15 closes to a form and contrasts with the surroundings or the ground. This makes the form perceptible. The course of the contour is decisive for the interpretation of the form and determines the expression of the form. The following example is representative for all contrast phenomena.

A circle has a typical contour, and a triangle has a different contour. The observer assigns corresponding terms (here: circle and triangle) to these different contours. Thus, form becomes distinguishable and describable. The results are different perceptual impressions. A circle has a different effect on an observer than a triangle. Here are the approaches for a creative knowledge that is applied in the design process.

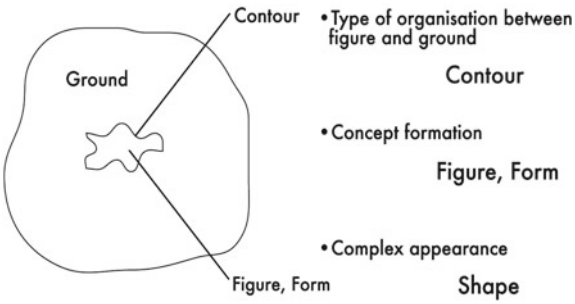

Fig. 6.15 Figure-ground relationship [Gatz-2013]

6.5.2 *Form and Shape*

The distinction of *form* and *shape* is important for practical design, as it allows investigations into the results of perception to be designed, Fig. 6.16.

A form is understood as a self-contained individual phenomenon. The contour encloses a surface form, and the surface course describes a spatial form. Creating a form or rather shaping a form means the design of *a contour* or *surface*. Contours and surfaces determine the perceptual impression.

- For the *area form*, the *course of contours* is the prerequisite for perception. The contour geometry determines the shape expression.
- For the *spatial form*, the *surface course* is the prerequisite for perception. The surface geometry determines the form expression.

Figure 6.17 shows an example of the relationship between contour and surface progression and their effects on an observer. This is the basis for a perception-oriented theory of forms, which is described in more detail in Sect. 6.6.

From the point of view of design, a shape is understood to be a group of forms. Shape formation describes the way in which individual forms are combined to form a shape. Different perceptual impressions can be consciously influenced by design options such as structuring and ordering measures.

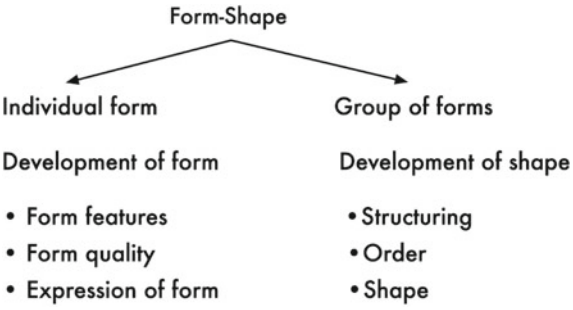

Fig. 6.16 Concepts of shape aesthetics [Gatz-2013]

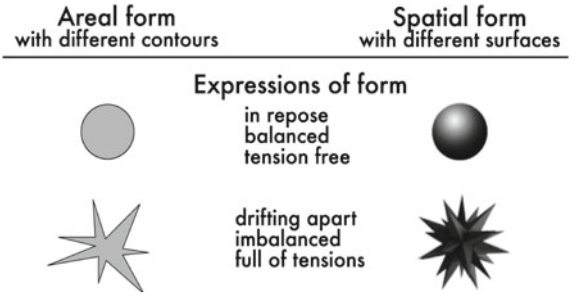

Fig. 6.17 Examples of surface and spatial forms and their different expressions

Form and shape in their geometric-material expression are the most effective elements in terms of perception. The human draws the most intensive and comprehensive perceptual impressions from the perception of form and shape. This is also the reason for the particularly intensive design debates in design processes.

At this point, the complexity of a shape appearance must be pointed out. A shape is not only a geometric group of forms, but the totality of the aesthetic elements form, colour, material and surface as well as their individual characteristics, such as the constellation of the design elements to each other. The *shape structure* describes the interaction of all elements of design aesthetics. It is only now that something arises what becomes a shape or design appearance that is a prerequisite, for e.g., complex product perception, Fig. 6.18.

Developing the shape of a product means dealing with a future situation of perception. The degree of coupling relationships between the aesthetic elements, described as the structure of form, is of great importance. This measure decisively determines the designed perception impression.

- The *shape structure* results from
- the type of design elements used,
- their quantitative distribution on the product and
- the relationship of the individual to the wholeness.

Depending on the conditions of the product, two perceptual impressions arise: the impression of order or the impression of complexity. Figure 6.19 shows the impression of order and complexity using the example of two clocks. Already this distinguishing feature leads to different effects.

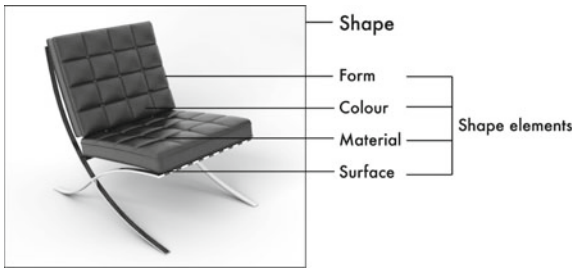

Fig. 6.18 Design structure (product example: Barcelona armchair by Ludwig Mies van der Rohe, 1929) [Gatz-2013]

Fig. 6.19 Different design structures with different effects using the example of wristwatches [Gatz-2013]

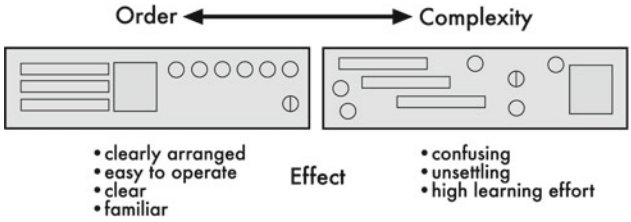

Fig. 6.20 Different states using the example of a radio user interface [Gatz-2013]

Order means:

- Small number of design elements
- Small number of arrangement properties.

Complexity means:

- Many design elements
- Many arrangement properties.

Order and complexity are the result of conscious design with the aim of achieving perceptible effects for the user.

Effects can be, for example,

- Simple—complex
- Clear—confusing to chaotic
- Expensive—cheap
- Old—new
- Interesting (attention)—uninteresting (indifference).

The example in Fig. 6.20 also shows how the two states order and complexity work.

Figure 6.21 shows a current example of the cockpit design of a car. The analysis only considers the design of the control elements. Other design features are not taken into account.

Above:

Means of design: Application of identical and related forms
Effect: High level of order appears to be tidy, safe to use and familiar.

Below:

Means of design: Application of the most varied forms
Effect: High complexity or chaos of forms is confusing, unsettling and irritating.

To sum up, it can be said that
Only the conscious design achieves the intended effect!

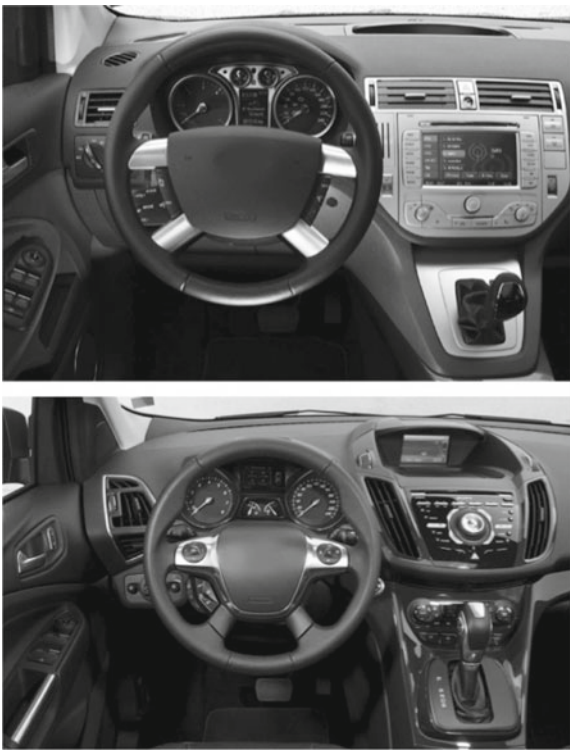

Fig. 6.21 Example for the cockpit design of a middle class car (upper picture: predecessor model, lower picture: model year 2013)

Figure 6.22 shows a graphic with two designs that consist of identical design elements but differ in only one arrangement. This small (design) difference makes the different effect.

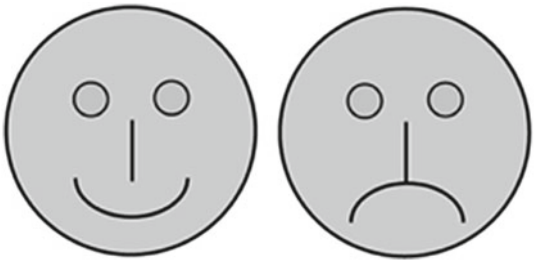

Fig. 6.22 Two designs made of identical design elements [Gatz-2013]

6.5.3 Design Rules

The examples show the connection between design and effects produced by the user. This also raises the question of applicable rules, recommendations, criteria and examples. JAKOBY gives a good overview with practical recommendations for perceptual design in [Jako-1993]. The recommendations are addressed to engineers and designers.

Unlike in mathematics, physics and technology, the application of rules does not necessarily lead to good results, i.e., well-designed products. In product design, it is always important to visually check the effects that occur on the shape of the product with the intended targets and to correct them if necessary. The design rules are based on the characteristics of the visual perception system. They represent regularities that are felt by all people to be almost the same and can therefore contribute to an objectivisation of creative action. In principle, all rules are based on the relationship between *order* and *complexity* back.

Reference should be made to design rules that are particularly important for product design. More detailed descriptions and examples can be found in [Jako-1993]. Only a few explanations will be given here to underline their relevance.

6.5.3.1 Qualitative Statements on Shape Formation

Strong, clear and concise design appearances are characterised by

- Regularity
- Uniformity
- Closeness
- Simplicity
- Symmetry.

According to [Ehre-1954], the following statements can be made for an overall shape and its partial shapes:

An overall shape is equal to the sum of its individual parts, but:

- The experience (impression, statement, evaluation,…) of an overall shape is clearly different from the sum of the experiences through the partial shapes.
- The perception of an overall shape takes place before the perception of its partial shapes.
- The impression gained by the perception of an overall shape dominates the perception of the partial shapes.

The additive assembly of the shape of a product only according to technical considerations does not necessarily result in a “correct” shape appearance developed on the basis of the sensory impressions.

6.5.3.2 Qualitative Statements on the Structure of a Shape

So-called laws of shape describe how points, lines (edges), surfaces and bodies can be structured and joined together with the elements in a way that is appropriate for perception. These laws are applied in product design.

6.5.3.3 Qualitative Statements on the Ordering of a Figure

Only through the conscious ordering of a shape, there is a development of statements like

Clearly arranged
Familiar
Useful
Easy to understand and
Sure,

i.e., statements that correspond to the goal of perception correctness. Designing order can be achieved by

- Classification according to specific criteria such as function, usage and significance
- Standardisation
- Simplification.

The degree of creative order can only ever be determined in connection with the design of the product and its product statements. What is right for one occasion may be wrong or inappropriate in another.

6.6 Introduction to a Perception-Oriented Theory of Forms

Basis of the methodical approach for a perception-oriented *theory of forms* is the assumption that the human sense of form is dominated by the perception of natural forms. Archetypal natural forms accompany humans in a permanent way, shape their geometric ideas of form and anchor interpretations and meanings. It is therefore obvious to use these natural basic forms and to transfer them to "artificial", i.e., man-made forms.

The aim is the design of effects on humans under the aspect of the way they perceive form.

In terms of developmental history, the sense of form can be derived from the perception of nature. It should be noted that natural forms are always the result of natural processes. The natural variety of forms is infinite and is not oriented to human standards and needs. The situation is different with forms created by humans. These designs reflect human needs and are based on human standards.

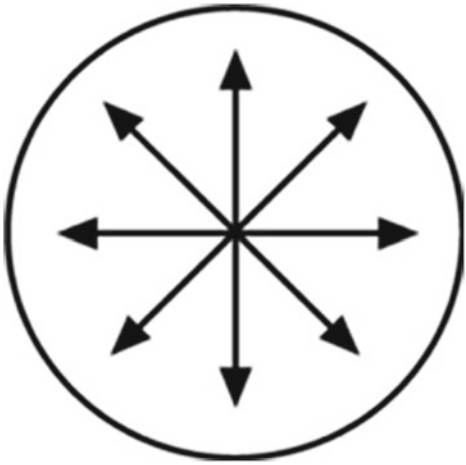

Fig. 6.23 Unorientet shape character [Gatz-2013]

Natural forms and forms created by humans give distinction to the human perceptual environment. Therefore, natural forms can also serve as a basis for a perception-oriented form methodology or theory.

The human *sense of form* is determined by the *contour course* for surfaces and the *surface course* for body shapes. A method for systematising the variety of forms asks for the direction of the contour or surface as distinguishing and ordering features.

The principle of distinctness is illustrated using the example of a circle in Fig. 6.23.

The circle is perceived as a circle because its contour has no direction. For the purpose of typification, its formal character is described as "unoriented". Following this principle, basic forms derived from nature can be developed.

Around the years of the 1970s, ZITZMANN created training foundations for designers at the University for Industrial Design, Halle-Burg Giebichenstein. The methodical systematisation of the forms described here goes back to these works [ZiSc-1990].

6.6.1 Form Methodology—Form Character

In the following, four form characters are derived from natural forms. The aim is a design-based methodology for distinguishing forma according to criteria of perception. With this methodology, it is possible to analyse forms with regard to their visual effect on a user and to apply them purposefully for design tasks. Moreover, this methodology offers the possibility of overcoming the often observed "speechlessness" in analysis and argumentation of and for forms, Fig. 6.24.

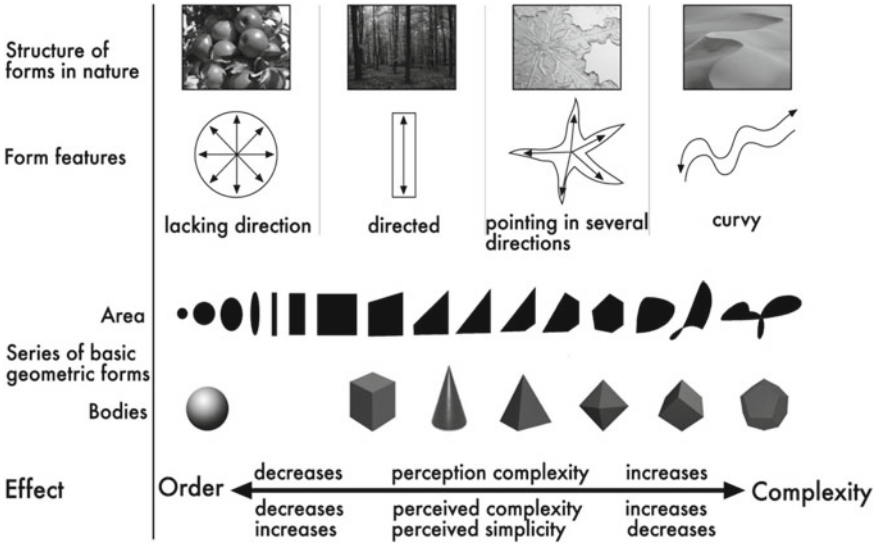

Fig. 6.24 Taxonomy of forms [Gatz-2013]

6.6.2 Taxonomy of Forms

As a result of the analysis of natural forms and their simplification to simple geometric basic forms, a taxonomy can be developed based on different perceptual efforts.

It is assumed, for example, that a circle is perceived faster, safer and more definite than a polygon or a complicated moving form. However, it is not only the perceptual effort that is a distinguishing or systematising feature, but also the different effect of the form on the observer. A circle is perceived as a calm, tension-free form, a triangular form, in contrast, as aggressive and often as moving.

From this observation, a series of forms differentiated by perceptual effort and triggered sensation can be set up, which is of great importance for practical design. A planned sensation that occurs in the viewer can be achieved with a high degree of probability by using the appropriate shapes.

6.6.3 Forming Quality

The taxonomy of forms provides important insights to the industrial designer for designing effects, because a further step towards the perceptual correctness of form lies in the consideration of the following three characteristics of aesthetic quality:

- The purity of the form,
- The continuity of the form and
- Transitional forms and details.

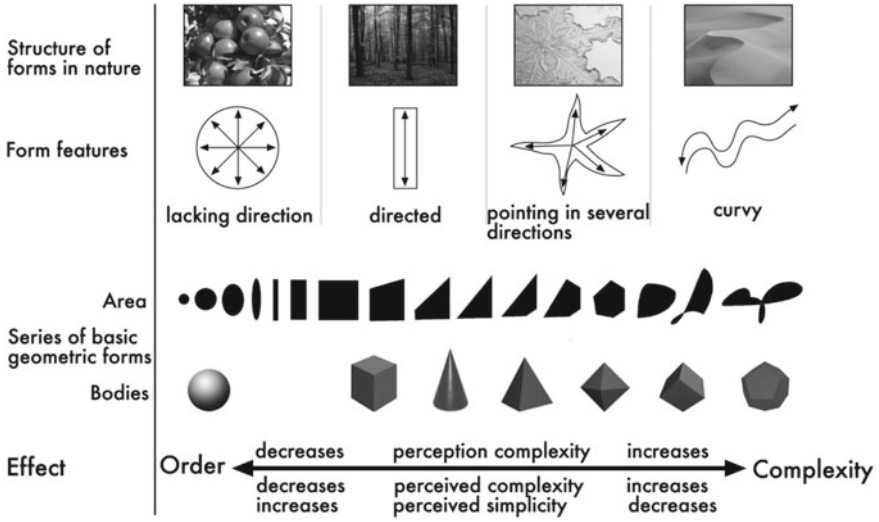

Fig. 6.25 Differentiation of body shapes according to the criterion of purity [Gatz-2013]

As soon as the goal of perceptual correctness is set, these characteristics can also be linked to goals. The aim is to achieve a high degree of purity, consistency and form locking (Sect. 6.6.3.1).

6.6.3.1 Purity of Form

The relationships described in Sect. 6.6.1 and the series of forms shown in Fig. 6.24 are now transferred to body forms.

For example, a sphere differs from a tetrahedron in terms of the effort required to perceive it and the effects it produces on the observer.

High purity as a quality characteristic of good design has a low number of species and form elements. Simple geometric side shapes, low number of surfaces and low number of edges are design features to be aimed for, Fig. 6.25.

6.6.3.2 Continuity of Form

The continuity of form is often associated with the impression of harmony and discontinuity with disharmony. If the "harmonious" form is the design goal, then certain features must be implemented in the design.

- Continuity of the course of a contour or a surface
- Continuity of direction and
- Continuity of curvature.

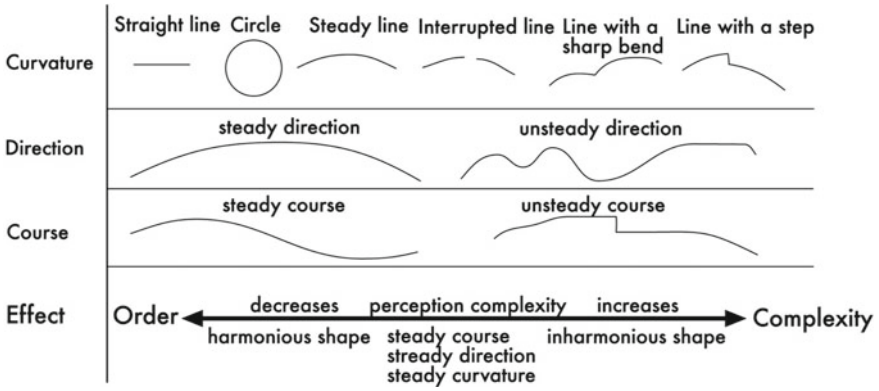

Fig. 6.26 Differentiation according to the criteria of the quality of the training [Gatz-2013]

Continuity of the course means not to allow any cracks and kinks in the form. Points of discontinuity disturb the harmonious impression and can be superimposed on each other in terms of design. One could also say that the eye "gets stuck" at this point. It should be noted, however, that kinks or jumps can be deliberate and intentional, for example if they are to be perceived as superimposition (special place of attention), Fig. 6.26.

As a third characteristic of continuity, there is an influence of perception by the curvature of a contour or a surface. The more complex the curvatures are, the more "disturbances" are felt, and, all the more, the form can appear disharmonious.

6.6.4 Design Methods for Perceptual-Oriented Design

The relation of *order* and *complexity* determines the degree and the characteristics of the shape structure. It is not possible to set fixed standards for this ratio. Too many factors influence the design trend. Social and cultural values, zeitgeist, individual perceptions, marketing aspects and design qualifications shape the ideas about this design problem.

And yet a design tendency and a recommendation for the product design can be derived. With industrialisation and the accompanying cultural-theoretical movements and changes, there is a clear tendency towards consciously ordered design phenomena. Attributes such as *simple, clear, understandable* and *honest* have become established as quality features in the design of the twentieth and twenty-first centuries.

Of course, their implementation requires complex professional design. However, the designer can also influence the perception of the design appearance in the process of form and shape finding. Two methods are particularly suitable for implementation in the design process, namely *form locking* and *form calming*, which are methods for increasing visual *order*.

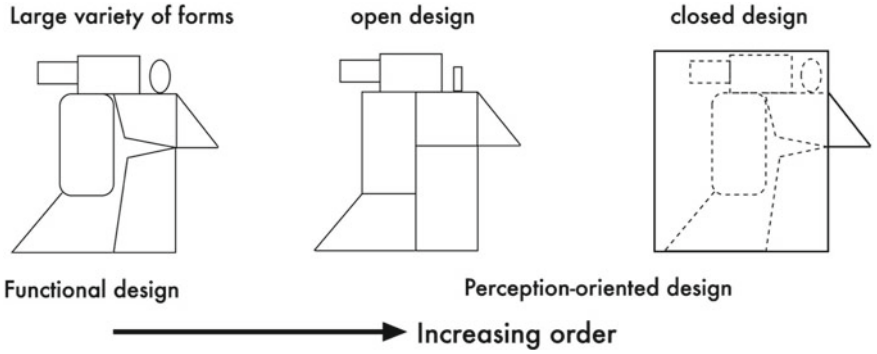

Fig. 6.27 Two methods for form calming [Gatz-2013]

Under form locking, the joining of individual forms to form a less complex form appearance is to be described. If the criteria of perceptual correctness are used as a yardstick, a very complex variety of forms can appear restless, unbalanced, unbalanced and overstraining. The functional shape shown in Fig. 6.27 is an example of a shape that is not perceptively correct. It arises when a design is created exclusively according to technical-functional requirements and without taking aesthetic considerations into account.

Design with the aim of simplifying and standardising forms is thus a step towards a form that is fair to perception.

In principle, two ways are possible:

- Composition of the form from identical or related forms is individually visible and shows themselves in an open design appearance. This creates the impression of openness.
- Masking of the variety of forms is by an "imposed over-cover" (cladding, housing). The variety of forms is concealed, and the cover takes over the aesthetic function of the design appearance. The impression of unity is created.

Both methods are common in practical forming and are known as form calming.

Figure 6.27 shows the design path from a functional form to a perceptually appropriate design appearance.

Form calming is a design possibility to make a creative decision between order and complexity of the perceived form. The degree of order to be created determines the intended effects.

As a design orientation and also as a quality criterion for design, a turn towards orderly form and design appearances can be observed. A high order of forms means effects like

- Clarity
- Transparency
- Security and safety
- Perfection

- Soundness
- High quality, high valence and
- Longevity.

The respective individual and social evaluation always takes place within a socio-cultural framework. Valuation standards and values are therefore dependent on time and culture. High order = high quality = premium = durable, for example, stand for design concepts that have been established as the standard since the end of the nineteenth century until today.

The methods of form locking and form calming are clearly favoured in product design, if the nature of the product and its method of use allow it. Open, understandable, accessible design appearances become possible. In consideration of functional and especially safety-related requirements, a disclosure of the design and operating principle shall be aimed at. The diversity of design forms is then reduced by a targeted simplification and calming of forms, so that a feeling of order can develop. The use of simple geometric basic forms is an important design approach.

The covering of a polymorphism often has technical reasons, especially safety reasons, because often the wrapping is also a protection against external and internal dangers. In this sense, it also has a protective effect. The visual effect is based on the principle of contraction. One does no longer see the diversity of many individual forms, but only the overall shape.

There is something calming about this, but at the same time, there is something confusing or mysterious about it. In any case, a cover has an ordering effect, since the shape of the cover can greatly reduce the diversity. Both methods are practiced in product design. Both methods can be used to order design phenomena or to reduce or calm their visual complexity. This method also supports the search for product identity via design.

Figure 6.28 shows an example of both possibilities. A bicycle usually has an open design. The form elements that determine function and use create an open, perceptible design appearance by applying the principles of engineering design and shape design (arrangement). The machine tool is closed by a cover. Here the housing design takes over the aesthetic function.

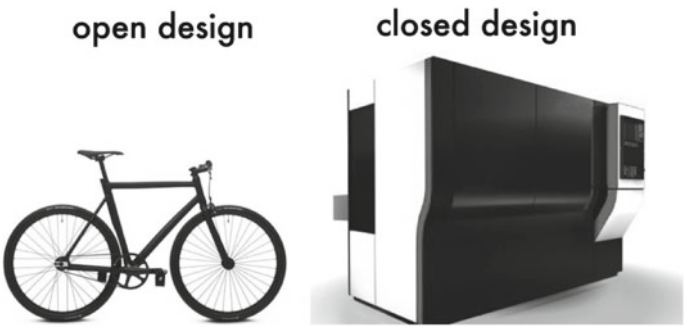

Fig. 6.28 Bicycle and machine tool as open and closed design-product examples [Gatz-2013]

6.7 Summary

Form and shape are the central functional and perceptual prerequisites for the implementation of technical and aesthetic product requirements in product development. If the product developer strives for functional fulfilment through form, the industrial designer creates the conditions for perception, which take place primarily in processes of use. Both stakeholders plan, visualise and materialise the geometrical-material entireness of a product against the background of their specific objectives.

The development of meaningful and perceptive design solutions is a decisive concern in product design. The approach for creative results lies in designing the interrelation between perception and behaviour. Perception, sensation and behaviour of a user or user group can be specifically influenced via the shape of the product.

A perception-oriented theory of form and shape shows the basics and connections, but also shows the directions to be taken in design. *Order* and *complexity* are two design directions in order to design the structure of the shape differently according to the intended effects. However, this exploits far from over the entire repertoire of creative decision-making possibilities. The trained industrial designer applies these possibilities with compositional skill and through the skills he has acquired in creative practice. A high degree of sensitivity for form, colour, material and surface aesthetics constitute the individual prerequisites for professionalism.

Product development generally is an interdisciplinary process. In order to bring out all the characteristics expected of a quality product, interdisciplinary and integrative performance is required, which can only be achieved in appropriate structural and organisational environments such as IDE. From the perspective of industrial design, the particular strength of IDE lies in the comprehensive consideration of humans not only as users of products, but also as their creators and developers, and as those who are not involved *in the* life cycle of the product, but are affected *by it*.

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