THE RELATIONSHIP BETWEEN A MODEL AND A FULL-SIZE OBJECT OR BUILDING: THE PERCEPTION AND INTERPRETATION OF MODELS

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ABSTRACT
There is a naive belief in models as a blueprint for objects and environments that goes back to the epistemology of The Enlightenment. In the manufacturing industry and in society, many decisions concerning new products or urban planning are based on models representing the actual object or area. Substantial experience is required to interpret models, especially when it comes to the effect different scales have on material, colors and volume. This paper will address theoretical aspects of our ability to interpret and understand the relationship between 3D-models on computer screens or constructions of models and the object in full scale.

Keywords: industrial design, model makers, interpretation of models, construction of models, computer screen models, visual perception, domains, property.

1 INTRODUCTION

Manufacturing companies are always looking for better ways to reduce costs and accelerate production in order to compete in today's global market. Industrial design model makers have long been given the task of creating prototypes. Prototypes are models that could be made in different ways, and they are expected to accurately reflect the form, fit, and function of the finished product. There are also expectations from the manufactory industry that the model maker should be able to add value in terms of improved usability and more appealing products. Computer-generated models or constructions of models can be prototypes of something that does not yet exist, or represent already existing objects. Nevertheless, models are artifacts by themselves: they are either virtual 3D-models or scale-models. Therefore, they can be interpreted independently without any consideration given to the object or phenomenon they represent. That is because a direct relationship does not exist between the representation and the object represented. Even though a model is a mathematically correct copy on a small-scale of a larger object, it will in many ways be perceived as an autonomous object. The relationship between the model and the real object has to be interpreted by the viewer. To be able to do so, the spectator needs specific competencies and experience of interpreting those kinds of relationships. This is seldom taken into consideration when using models to represent objects that do not yet exist. In urban planning, disagreement regarding how to interpret the model construction of the actual area or buildings represented is common. Will the new house or area hide the water view? This discussion is relevant to apply to the context of industrial design, since the use of models as a representation of a planned product realization is common in both contexts. Therefore, it is important to bring up questions about the capacity of the human being to interpret models in general in order to understand how effective and efficient the use of models is in industrial design. This leads us to a discussion of what has to be demanded of a model in order for it to be valuable in industrial design.

1.2 Objectives

This paper will address theoretical aspects of the ability of people to interpret and understand the relationship between 3D-models on computer screens or constructions of models and the object in full scale. The overall objective of this paper is to present some influential theories about visual perception and visual thinking and apply them to the practice of creating models. From that, we will formulate and address a theoretical perspective regarding the complexity of understanding the relationship between a model in small-scale and a work in full-scale. One of the aims is to initiate a discussion

about the difficulties in the actual interpretation process. We will present a list with crucial aspects to be considered when using computer-generated models and model constructions. We do so in order to avoid some crucial mistakes when using models.
The research questions of this paper are the following: What do theories about visual perception offer concerning the perception of models in an industrial design context? Is it possible to give general suggestions concerning how computer-generated models or constructions of models should be designed in order to facilitate interpretation of intended meaning?

2 STATE OF THE ART

2.1 Models in education

Models that represent real objects and phenomena have a long history. The purpose of making models varies regarding context. In military history, we find models of soldiers, horses, ships and equipment for battle. The models were used in order to plan different battle strategies in war and in the military education of soldiers. In primary school, models of plants, animals and human bodies were frequently used from late 19th century until the 1960s or 1970s, when the models were replaced by richly illustrated textbooks. The introductions of models in primary schools are based on an epistemology that goes back to The Enlightenment and the development of empiricism. Empiricists advocate that it is necessary to get input from several senses in order to gain knowledge and understanding of the surroundings. The pedagogues suggested that the outlook education expected that the models could, if necessary, replace real plants, animals, the human body and buildings and offer necessary sense data. They considered models as a step between real objects and pictures, and stated that it was important to go via models in order to learn the interpretation of pictures [1]. In late 1990s, there were expectations that interactive computer programs would replace physical and chemical experiments and exercises in primary school. Ten years later, we realize that this is not the case. The reason for this is two-fold: it is expensive and complicated to create software that facilitates the pedagogical demands [3] and the bodily experience of doing an experiment is missing. There is a big difference between performing a chemical experiment through mouse clicking and combining different liquids by pouring them into different goblets [2]. It is important to emphasize that models of different kinds play a crucial role in primary school education since they help the children to better understand phenomena, especially abstract phenomena such as the inner organs of a body and relationships in physics and chemistry. In chemistry, models of different kinds are fundamental for the understanding of molecules.

2.2 Models in industrial design processes

Models and sketches within industrial design have been studied from a human cooperative approach. There is agreement among scholars that any type of activity (and, by extension, cooperative ones) is mediated through the usage of artifacts. For example it could be sketches, notes or models. Rabardel and Vérillon developed a theory concerning the use of artifacts in human cooperation in the French elementary school context. The theory has its heritage from Piaget [4]. Scholars like Barbara Tversky emphasize that sketches facilitate creative processes since they will deliberate memory [5]. Contemporary research suggests that the sketch is more efficient than a CAD-model in the actual design process [6].
The sociologist and art critic Kathryn Henderson has explored the use of both computer graphics and traditional paper sketches in an engineering design context, presented in 1999 in her book *On Line and on Paper* [7]. A finding of particular interest to highlight in relation to this paper is the use of these two different types of visual representations (that is, in what way and when the design team uses the two different kinds of visual representations). The choice of which type of sketch or model is related to what part of the design process it relates to, namely what part of the development of the design it is connected to. The use of computer graphics or CAD-models is used by the design team in a formally decided phase, i.e. when the design is already established. It is seldom this type of visual representation is used to communicate suggestions among the team, during the design processes. In that activity, the examined teams prefer the traditional on-paper sketches.

2.3 Models as a tool for communication

Contemporary designers usually works in team, and in that context the model works as a boundary object for the team and have an important collaborative role in the team. [8]. However, in this paper we focus on the role of the model in a business to customer relation. Therefore the discussion will bring up how models are used in industrial design, as mockup or prototype. This is the step between a sketch and a produced object. In this discussion, we leave out the prototype since it is a full-scale model that offers the possibility to exam the function of the object. A model is expected to give a more realistic view of the future object or building. Models are less abstract than sketches. As a result, they do not demand the same effort from the viewer in terms of interpretation as a sketch does. However, there is a huge difference between a collaborative work around a model and interpreting a model made by an industrial designer and showed for a costumer. Even though a model is an external object, it is still interpreted differently between single individuals. This is because the interpretation act is dominated by mental images. This will not cause problems if there is a final product, but a model of an object not yet existing is a suggestion of something to come. What has to work in this is the mental image of the model in full-scale. Therefore, a fundamental question is: to what extent is it possible to interpret the relationship between the model and an object or building not yet realized?

3 THEORETICAL FRAME

As mentioned before, a model is expected to give a more realistic view of a future object or building. Scale-models offer more than a visual view of an object: they can be touched. 3D-models on a computer screen are not tangible, but they give an illusion of tangibility. A scale-model is always possible to observe from different angles, while a 3D-model on a computer screen can be either fixed or movable. However, visual perception is a multimodal process, regardless of whether it is the environment or a picture that is observed. A visual act is always a multimodal one that involves the whole body [9] since human beings perceive the environment by using all the senses. Moving around is a kinesthetic process in which touch, muscles and movement are included. The British psychologist Susanna Millar emphasizes that an understanding of space and our ability to move around can be explained by the fact that all spatial experience and understanding emanates from the axes of the body (Figure 1) [10].

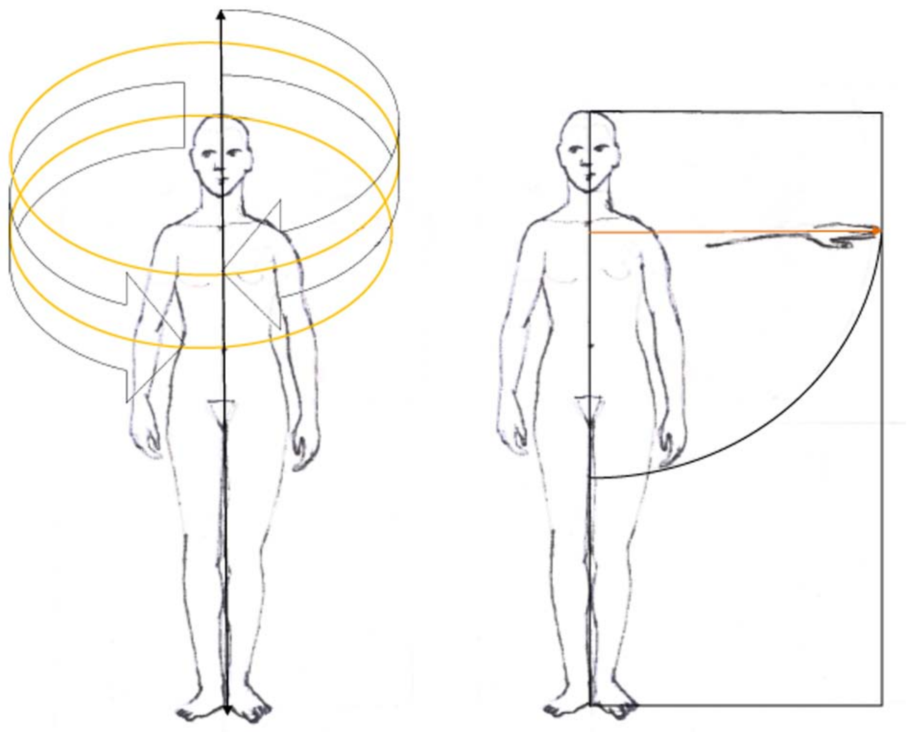

Figure 1. The limits of understanding space and proportions connected with experience emanating from the center axes of the body, the grounds for an understanding of size relations and proportions.

Size is also a bodily experience; therefore, the memories of all places from the childhood are much larger than in reality. In many cases, a scale-model of an object differs radically in size from the real object. Concerning phenomenology, this will have a large impact on the impression of the experience and, thus, the understanding of the model as something that should be realized on a considerably larger scale. Many young designers of today work exclusively with computers, and, therefore, construct computer-generated 3D-models. They have gained their experience and knowledge from using computers rather than making carbon models. Many of them have gained inter-medial skills, since they have used and learned from computers already in school. There is, however, no indication that they will have a better understanding of the relationship between the 3D-model and the actual object than traditional model-makers have, working with carbon models, for example.

While looking at an object or a representation, earlier experience is used. That experience relates to memory. Therefore, a picture can evoke memories of different kinds: they can be sounds, smells and softness, even though it is only a sheet of paper covered with pixels. A visual perception act is dominated by familiar objects or details that differ radically from what is known. Thus, individuals notice the known or diverse. Visual perception is an active act where one navigates between the known and the unknown. Concerning *Gestalt theory* and *Gestalt laws*, shapes and groups of objects are recognized that could be discriminated [11]. The foreground is distinguished from the background. To be able to do so, the eyesight creates contours around objects. In reality, the contours do not exist. Rather, they are used to draw the outline of figures in sketching and drawings. It is the outlines that make the shape or form. Crucial for recognition is similarity in shape between an object and the representation of the same.

A scale-model does not facilitate or offer any specific point of view. It is an object that is possible to either walk around or to move and turn around on the computer screen. As such, it is not possible to control the viewers' perception, as in a 2D-drawing. Fundamental for visual representations are the similarities with the actual object. Similarity is, however, a complex concept, since it is experienced differently as a result of context and cultural traditions. According to *Gestalt theory,* similarities are to be found in the shape of an object. The shape is formed by the outlines or contours of things. We will identify a green fox in a sculpture or picture from its characteristic shape and more or less ignore the inappropriate color.

The Australian philosopher D. M. Armstrong has addressed different kinds of theories about how human concepts are structured [12]. This explains how we can decide how similar a new phenomenon is to an old one. His theory is useful in discussions about similarities in relation to models and the represented artifact. Armstrong distinguishes between different *domains*. Spatial concepts belong to one domain, color concepts to another, and sounds to a third, and so on. In cognitive science, it is necessary to separate information to be represented into different domains. Analogous to the discussion about concepts within cognitive science, the distinction between domains is useful when defining different kinds of models and their ability to represent actual objects.

3.1 Different domains to be found in a model

By using a framework for theories about representations, it is possible to deconstruct a model as such and gain a deeper understanding of the ability to relate it to an actual object, whether it is a representation of an already existed object or not. A scale-model or construction of a model can be interpreted from different domains. The major domains for construction of models are material, volume, dimensions, shape and color. The different domains can be divided into several *dimensions*.

Material is a domain that effects the perception of model. A model in white cardboard does not mediate any material qualities of the actual object; it belongs foremost to the domain of cardboard models, which has its heritage in the architect model context. On the other hand, models made in the same material as the actual object do not necessarily have the same visual effect, since the scale affects the appearance of the material. Sometimes the material could give similar tactile experience, and it will belong to the same domain of material. The perception of and the experience of different concepts is a multimodal process. As such, varieties of quality can therefore effects which domain the model will belong to. Tactile experience and visual experience of objects are not always the same. A marble surface can look soft. A metallic surface can have a pleasant and warm color, but the tactile experience is coldness because of the capacity of the material to lead heat.

In connection to the theories about domains, the cognitive scholar Peter Gärdenfors discussed the invariance in our perceptions that corresponds to assigning *properties* to the perceived objects. He argues that properties should be seen as a special case of concepts [13]. A property is something that objects can have in common. If they have a particular property, they are *similar* in some respect. For many properties, there are empirical tests to decide whether a property is present in an object (in particular, when they are perceived as having a specific property. Before we go into the discussions about the relevance in those theories concerning models for industrial design, we will define the ontology of models.

4 THE ONTOLOGY OF MODELS

In an abstract, simplified view, the two types of models discussed in this paper can be characterized as follows in Sections 4.1 and 4.2. To highlight the different aspects concerning the two types, *Figure 2* offers a summarized view of the most important aspects of the examination and characterization. The sights used are the *model makers' skills* and the *interpreters' skills*. The interpreter could be a customer or a politician, for example, when it comes to architecture models. Similarities as well as differences are detected.

Figure 2. Interpretation, skills and type of model.

Type of model	Techniques used	Model makers´ skills to consider	Interpreters´ skills to consider
Scale model	Traditional crafted models in paper, cardboard, wood or plaster.	**Craft**- being skillful in the use of tools to perform exact cut in: paper, wood, plaster, etc. Fix parts in position **Blueprint or map** being able to read it for scale information, etc. **Define positions-** landmarks **Measure-** translate and relate **Interpret**- relationships not revealed in map or blueprint **Position-**define relation to surroundings **Ground-** background, object relationships **Shape-** space, inner and outer **Balance**-understanding diverse objects' impact on each other **Colors** knowing how to blend colors in“ scale”	**Landmark-**define position and mark out within the model **View point-** position of eyes related to the “mini world” the model is representing **Size-**represented coming objects' size **Position-** being able to understand relations to surrounding objects **Ground-** background, object relationships **Shape**- reading space, inner and outer **Color**- understanding representation of color in coming full scale object
3D model	3D- models displayed via computer screen.	**Craft**-being skillful in a CAD program **Size-**how to represent relationships (solution: add an object that in relation with assumed size agreement reveals proportions) **Position-**relation to surroundings **Ground-** background, Objects' relationships **Volume**-understanding inner and outer volume relationships **Proportions-**consider proportions in parts and in whole **Light**-use as position indicator, time indicator or relationship	**Size-**represented coming objects' size **Position-** being able to understand relations to surrounding objects **Ground-** background, Objects' relationships **Shape**- reading space, inner and outer **Volume**-understanding inner and outer volume relationships **Light-** understanding what light indicates: time of day, relation to other objects, time of year, etc. **Color**- understanding

		indicator **Color** - representing color in full size object, fine-tuning **Shape-** space, inner and outer **Balance**-understanding diverse objects' impact on each other **Basic form elements-** being able to use and combine basic forms as: cube, cone, sphere to create complex forms.	representation of color in coming full scale object

4.1 Construction and interpretation of scale models

The first type, the *scale-model,* is a traditional model produced in paper, wood or plaster. Today, scale-models are mainly used in architecture planning, where they play a central role for decisions about what buildings, areas and whole parts of cities and infrastructures will be realized. Scale-models elucidate the central aspects of the relationship between a model and artifact that is represented. At first, the architect or industrial designer's skills in model making has to be considered. The ability to use tools to perform exact cuts in paper, cardboard, wood or plaster is essential. The model maker must also be able to read and relate to a blueprint or map, getting the exact information of scale, positions, functions and relationships. Next is the matter of defining positions, establishing landmarks and creating a zero point, both for measurable relationships between objects the model is planned to represent and the relationships of more subjective character, such as color and shade. It is only a matter of experience when it comes to blending colors in "scale".
Crucial for the outcome is the model makers' ability to interpret relationships not revealed in the map or blueprint. It is a matter of translation and relating, not simply calculating. Relationships to the surrounding are an additional difficulty in this process; there is no frame or border between the small-scale model and the surrounding full-scale room. Therefore, imaginary positions fixed in the small room are necessary to define to be able to decide the foreground, background and relationships of an object. To place a familiar object, including an adult man in the model is a way of showing size relationships. To be able do all this, an explicit understanding of shape, form and space is essential, as well as an awareness of the concept inner and outer space. Paying special attention to balancing the impact of diverse objects on each other is a further concern. It is a complex act comprised of decisions, based on experience.

When it comes to the interpreters' skills, they partly correspond to the model makers' skills, but from the other point of view. First to consider is the definition of landmarks, positions marked out within the model to relate to. Another is the choice of viewpoint**,** i.e. the position of the interpreters' eyes related to the "mini world" the model is representing. This view position is necessary to have a chance to get the same bodily experience and understanding one would get if it were real size [14]. In addition, the interpreter has to understand scale representations and be trained in the translation of coming objects size, a difficult task.
Nevertheless the interpreter has to understand relationships to surrounding objects' positions and size on the whole, plus the concept of foreground and background, in short objects' relationships presented in the model. Another skill of the interpreter is the understanding of shape and form in addition to interpreting space, inner and outer as well as the relationships they represent. Shapes are concepts. The art psychologist Rudolf Arnheim states that "what matters is that an object at which someone is looking can be said to be truly perceived only to the extent to which it is fitted to some organized shape." [15] The understanding of color, or to be exact, the understanding of the *representation* of color in the model and relating to the coming full-scale object "color in scale" is a matter of decoding the model maker's experience of blending color in scale, which is, as said before, a subjective, experience-based matter.

4.2 Construction and interpretation of 3D-models

The second type discussed in this paper is the *3D-model*, produced in a CAD-software (Computer aided design). This section concerns 3D-models (computer-gained visual representations) and the processes used when producing these models. There are several different software programs offering

the opportunities to make three dimensional models and sketches. This section will not discuss specific program-related issues; instead, it will focus on general considerations when making 3D-models as well as when understanding them.
In industrial design, the model makers' skills are, by necessity, first and foremost CAD-software skills. To start, the 3D-model makers have to import a blueprint or map (if there is such) and set up measures and ground data. The computer display is often divided into four views with plane projections from each side and from above, together with a 3D view. The model maker can chose to use all four or focus on one of them at the time. The flat projections are connected with rulers and expose measures. But the 3D view offers a simulation of a model in three dimensions. Regardless, when the construction of the model takes place, it is performed in a conceptual way, with basic form elements as grounds for all additional steps. The three forms cube, cone and sphere are the basis in the future design development, and the different geometrical forms belong to different domains. Being able to use and combine basic forms is the key knowledge in the making of this type of model. Next issue is to represent size relationships. Size is experienced and interpreted in relation to one's own body and in relation to other objects. One solution is to place a familiar object in the 3D-model that has a recognizable relation with the assumed size agreements and relationships in the model (often an adult male). The consideration of position (i.e., the relationship the model has to its surroundings and how to understand what is foreground or background) is a difficult part of the process; the scene metaphor is perhaps the best way to describe this. The model maker has to regard the display as a scene and define a stage and scenery. This is necessary in order to regard object relationships. In the scene, the model maker then can understand volume and shape and relate inner with outer volumes, proportions and parts in the completely**.** The next problem is the lightning that can, in its best use, function as a position indicator, time indicator or relationship indicator in the scene. The color that presumes represented color in the coming full size object is a matter of fine-tuning and experience. On top of all components in creating a 3D-model, the model maker has to understand how diverse objects impact on each other to be able to balance the scene. Finally, chosen angle and sight are crucial for what is exposed in the rendered flat picture of the 3D-scene. Most often the presentation of the 3D-model is completed in some sort of flat representation, rendered on paper or projected. The 3D-model is more seldom projected directly from the computer and shown as it is made, directly from the CAD-program, to the customer. Therefore, the interpreter is not able to rotate the model, as the model maker has been able to do while constructing it.

As in the previous example discussed interpretation skills to consider when reading 3D-models are scale models, a parallel to the model makers' skills. First, it is a matter of understanding object and size: one must be able to grasp the suggested size of the represented objects to come. Next is the consideration of the presented objects' positions, as well as relationships to objects in the surrounding environment. To do that, it is crucial to be able to understand the notions foreground and background. Furthermore, sorting out and reading space, shapes, forms as well as the considerate dissimilarity of inner and outer space is important. Then it is the interpretation of volume (i.e., the familiarity of inner and outer volume relationships) that is critical. As regards the light issue, it is a matter of awareness of what light is indicated in the examined model. Is it time of day or is it time of year or perhaps the relationship to other objects in the model that forms the shades? The same relationship of light and shades can expose different things. How does the interpreter know which? Finally, the concept of color in the model is, as earlier notified, a representation of color in the coming full-size object. It is a matter of fine-tuning and experience that the model maker possesses. Is it actually possible to value this representation and relate it to suggested colors in coming full-scale objects?
This is a tricky concept. In this case, it is not only the relationship (color in scale) that is key. It is also a matter of suggested materials, suggested time of day, suggested time of year, etc. [16]. In the 3D-model, it is possible to "dress" an object with material imported from a photographic image that contains the desired material and just paste it on the 3D-object. The understanding of the suggested material's outcome will be different if it is rendered as a day light version or if it is presented as a shady afternoon view in the autumn. The light in the model will change the color outcome. Therefore, identifying what time of day, what time of year or what sort of lightning that is represented is a concern of the interpreter. From that, he or she can interpret the represented color of the object.

4.3 The use of models

Models offer the ability to gain a graspable understanding of a final product. In models, three different relationships exist concerning size: a small-scale model for a large, full-scale object; a one-to-one relationship when the model and the object have the same size; and a model that has a larger scale than the object itself. The third relationship occurs, for example, when a goldsmith describing a design with small details for a customer needs to present it in a larger scale or complex components too small to be discussed using actual size (Figure 3). Common for all three examples is that it is possible to gain access to the actual object from several angles. In full-scale models of smaller artifacts, it is possible to get an understanding of the objects' ergonomics. Examples of this include if bottoms are a suitable size, or whether the space between them is good, or if the surface is pleasant to touch. Another aspect is the color, and color contrast that could be tried out in a model. However, it is more complex with large-scale models of objects. One example is train and railroad coaches. In those situations, ergonomics and functionality are hard to investigate from a small-scale model. It is one thing to place a paper model of a human being in a coach to illustrate the size relationship in a coach interior, and another to actually move around in a coach. This is especially true in a train bistro, where the staff have limited space in which to work and serve food and drinks packed in drawers. The bistro requires space for the staff to move and work. At the same time, it should be convenient enough for the passengers to pick up something to eat either to go or to stay in the bistro. Therefore, a full-scale train model is to prefer over a small scale-model. When it comes to architecture, a full-scale model is not possible: a building or an area will always be presented in another scale. Here, a map or a plan drawing can be helpful to get an overview of relationships, such as the extent of a building or area. A map indicates the space between the buildings, but still it is hard to imagine a future building or area that does not yet exist. Many local politicians have been criticized for making wrong decisions in relation to new buildings or areas; unpleasant areas with far too high buildings, too little space between them and no parks, plant or trees, for example. They defend themselves by referring to the architect models with many trees between the buildings and wide roads that allow light to come into the departments from the windows. Their interpretation is based on the idea of finding a direct relationship between the model or area and reality. They look for familiar properties to get a conception of the future building or area. Showing an object on a larger scale than reality causes other problems that doing the opposite (showing an object on a smaller scale) does, especially when it comes to design of jewelry. A mounting of different stones in a ring shown on a larger scale will probably create expectations the final ring cannot meet, especially if the customer is not used to interpreting models of jewelry. Meanwhile, a larger scale will facilitate the engineers' interpretation of the tiny components and their relationships.

Figure 3.

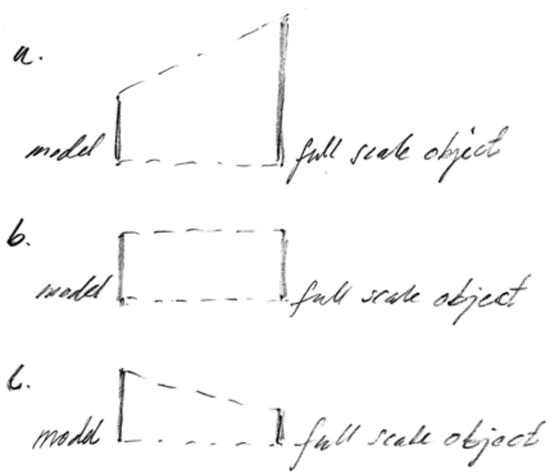

*Figure 3. Presents the three different size relationships discussed in Section 4:3: **a.** A small-scale model representing a large, full-scale object; **b.** A one-to-one relationship between model and final object; and, **c.** A model on a larger scale than the object itself.*

5 DISCUSSION AND CONCLUSIONS

Initially, we asked what theories about visual perception offer concerning the perception of models and how it can aid models in an industrial design context. According to Armstrong, concepts belong to different *domains*. Domains can be defined from properties. If objects have the same properties, they are similar. In this paper, we have brought up the problems of a naive attitude in relation to models and its similarity to the actual object. Property as such has to be elaborated in this context. If one looks at a model of a wheelchair, it has the same property as a real wheelchair, even though it differs in scale. It is also possible to analyze the wheelchair as regards different details and put details such as the seat into the domain of seats and the wheels into the domain of roundness. When the color and material are analyzed, there will be problems in relation to property. The same color (i.e. a color given a precise notation in the NCS, Natural Color System) gives different effects depending on the size of the surface. If the same color is used on the model that is used on the real object, it will still belong to the same domain in the color circle. But the spectator will not perceive it as similar. Therefore, it will not have the same property. Arnheim defined shape as a concept. The model of the wheelchair will be perceived as similar as the real wheelchair. The key shapes, and of course functions, for a wheelchair are the seat and the wheels. However, this example supports the naive idea regarding the similarity between models and real objects. At the same time, it also holds for a discussion about the complexity of interpreting models as representations of objects that do not yet exist.

Initially, we asked: what do theories about visual perception offer concerning the perception of models in an industrial design context? By being aware of the difficulties involved in interpreting models as representations of full-scale objects, the industrial design model makers can guide the customer through the model. They can help him or her to take the correct view position and discuss scale relationships, both in the actual environment and to the customers' bodily relationships. From our point of view, this is necessary regardless of whether the model is computer-created and 3D or crafted. Today, the size of a man of average length is used as a reference point. Since the length of humans differs radically, it could affect the final result dramatically (especially regarding ergonomic aspects). An interior of a car, or the seats in an underground train, look perfect in a model related to an abstract model of a male human being of average length. The model of a human belongs to the domain of human beings. Therefore, it is easy to make the mistake of interpreting the figure as having the same property as oneself, even if the figure is 20 centimeters longer than oneself. The understanding of properties is something empirically experienced, as suggested by Gärdenfors and others. However, one has to have in mind that model properties are abstract and have to be interpreted as having the same properties. We suggest that property in models related to real objects is experienced from body axes and individual size and length. In order to get a full understanding and a more correct interpretation of a model, customers need help in the interpretation process.

The second question addressed was: is it possible to give general suggestions concerning how computer-generated models or constructions of models should be designed in order to facilitate an interpretation of the intended meaning? With special awareness of the tasks that are difficult in principle, theoretically discussed as domains in this paper and highlighted in a summarized version in Figure 2, the model maker may well pay special attention to specific areas. With a higher awareness of these concerns comes the possibility to define specific instructions addressing potential interpretations of the model. We suggest that by providing the spectator with helpful instructions (for instance, with reference to where the position of view ought to be when interpreting the model), the model maker can ensure that he or she can correctly relate to the model. It is the industrial designers' consciousness in the process of making the model that is critical here. All the concerns presented in Figure 2 can be supplementary to the objective of transmitting a design concept and helpful in the goal of cutting costs. There will likely be a smaller amount of misunderstandings based on interpretation, and decisions may be made with fewer errors.

Finally, this paper has brought up some theoretical aspects of the relationship between models and reality, or between the real objects the models are supposed to represent and the models themselves. However, there is a need for further research in this area of experimental kinds in order to learn more about what is demanded from a model to be fully understood.

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