5 ORGANIZING DESIGN PRECEDENTS

In chapter 3 the concept of a product type was introduced as an organizational structure for design knowledge. By grouping product samples based on shared functional, perceptual or abstract features into such a product type, the product-specific knowledge of these samples becomes organized on a problem-independent level, affording a transfer to new design situations. The experiment of chapter 4 showed that providing designers with product samples which were visually grouped into product types, had a beneficiary effect on the results of their design process. At the end of chapter 4 the concept of a visual database of design precedents was introduced as a possible tool to support the designer in the generation and development of new product forms. The core of the database would be a collection of products, which are organized into product types based on their salient features regarding function, form and meaning. However, should the design of such a tool be directed towards a database which is presented to designers as a complete collection of pre-organized product types? Or is it more meaningful to provide them with an 'empty skeleton', in which the typological framework is already in place, but where organizing the products into types is left to the designers themselves?

To explore the feasibility of the latter approach a study was conducted in which the organization of design precedents was put into the hands of the designers themselves (Pasman and Hennessey, 1999b). In an experiment designers were asked to perform an organizing task, which involved arranging, grouping and naming four collections of existing products. Section 5.1 explains the design considerations which provided the motivation for conducting the experiment, as well as the issues that were addressed in it. The organizing task is

then described in section 5.2. It is presented separate from the description of the experiment, because of its possible application as a procedure for indexing products into a database. The task, which consists of three sub-tasks, is discussed in detail, illustrated with the most striking general observations and findings from the experiment. Section 5.3 then describes the actual experiment, in which two groups of design students performed the organizing task, with one group receiving additional information in the form of a design brief. The presentation of the results concentrates on the differences and similarities between these two groups. Finally, in section 5.4 the main findings are reviewed on their implications for the design of the visual database.

5.1 Design considerations

A large, pre-organized database, containing numerous design precedents from different product classes organized into many product types, and covering a large solution space, would provide the designer with a valuable body of expert design knowledge to consult during the design process. Through his experiences with the system, the designer would also get acquainted in a non-obtrusive way with the typological structure underlying the database. Thus he might apply this structure to support the analysis of and synthesis into new design situations.

However, such a pre-organized database implies that all design precedents which act as records in the database, have been classified by one or more experts on the criteria which were listed in the three product typologies. A possible procedure for this has been used in composing the product types in the previous design experiment. Clearly, to build up a substantial collection following this or a similar procedure requires an enormously elaborate and time-consuming process. Moreover, new products emerge every day, so a service organization would be needed to constantly update and maintain the database. Obviously this approach would not be very practical in a real application.

The problem is by-passed with a database which may have a starting set of examples, but is essentially organized, maintained and extended by designers themselves. The activity of classifying design precedents would encourage designers to concentrate their cognitive efforts on organizing, retrieving and

reviewing meaningful knowledge into and from the database, forcing them to attentively observe and compare products on different levels of detail and abstraction, thus enhancing their sensitivity for design details and nuances. In this way the database would become filled with information about the typological relationships between the products regarding function, form and meaning. An indexing procedure, through which this relational information is established, should thus be an integral part of the interface of the database. But how then should such a procedure be staged?

To successfully address issues such as the ones discussed above, it was felt that a better understanding was needed of how designers actually organize design precedents. Do they make spatial lay-outs, comparable to collages, when organizing products and can any relational information from these lay-outs be used to index products into a database? Do designers spontaneously organize products into groups, and to what extent can these groups be fit into the three previously constructed product typologies? And how much agreement is there between designers and what is the influence of additional factors, such as different product classes or a specific context as set out by a given design brief?

An organizing task, in which subjects had to arrange, group and name a collection of product samples, was designed as a possible procedure for indexing precedents into a database. This task was then used in an experiment, in which two groups of design students performed the task, with one group receiving additional information in the form of a design brief. Analyzing the data from this experiment focused mainly on identifying and describing overall patterns, concentrating on global observations and impressions rather than individual characteristics. Statistics were used mainly to illustrate the big picture rather than to pinpoint detailed differences. The results from the analysis were reviewed mainly in light of the development of the proposed visual database, although some observations regarding content were also made.

5.2 The organizing task

The following organizing task was designed as a possible procedure to organize products into a database. It consists of three sub-tasks, in which subjects have to

organize a collection of product samples. In the first sub-task the samples are to be spatially arranged, in the second sub-task they are to be grouped, and in the third sub-task they are to be named. Figure 5.1 shows a subject performing each of the three sub-tasks.

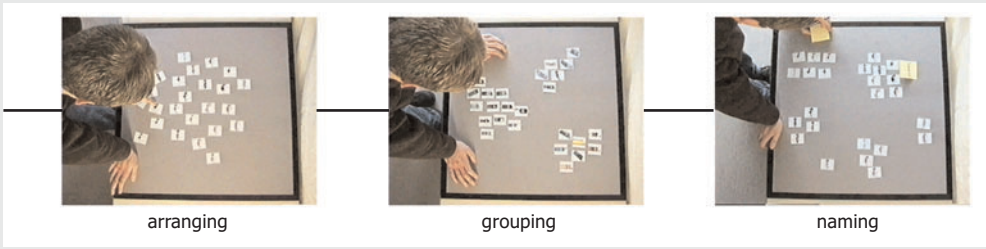


Figure 5.1 Subject performing each of the three sub-tasks

By staging the organizing task in this way, the amount of freedom given to the organization is gradually reduced with each sub-task, thus obtaining a graded commitment from the subjects performing the task. Having the subjects making spatial arrangements before doing the actual grouping makes this study different from other studies in which people were asked to sort products, such as Morel (2000) and Miller and Kälviäinen (2001).

Set-up

Using a joint-construction system a large frame was created, in which a table was placed upon which the subjects performed the task (Figure 5.2). At the top of the framework a digital photo camera and a Hi-8 video camera were mounted in such a way that the actions of the subjects could be recorded without hampering them while doing the experiment. The photo camera was used to take pictures of their work at the end of each of the four tasks, while the video camera recorded the whole experiment as a back-up. Four wooden boards, 75 x 75 cm, were made, on which a square of 70 x 70 cm of grey paper was glued. A square was selected because it does not impose a certain direction, like horizontal or vertical, on to the subject's organization.

Four product classes were selected to be organized: perfume bottles, mobile telephones, sunglasses and wristwatches. A justification for this selection

will be presented in section 5.3. Images of samples from each of these four classes were collected from various Internet sites, mostly those of manufacturers. These collections were then reduced to a total of 25 samples for each class, representing a cross-section of the total supply regarding form, use, color and meaning. Using image processing software each product image was brought to a size of 120 x 150 pixels and given a neutral grey background. Finally each image was printed in color on a card of heavy paper, size 4.23 x 5.29 cm, which was given a plastic coating for protection. All images can be found in Appendix C: Stimuli. Figure 5.3 shows a subject performing a task with the cards in the set-up.

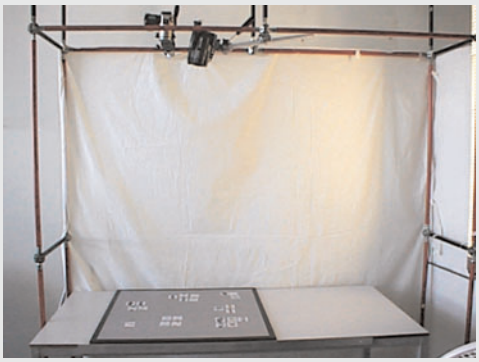


Figure 5.2 Set-up with video camera and photo camera

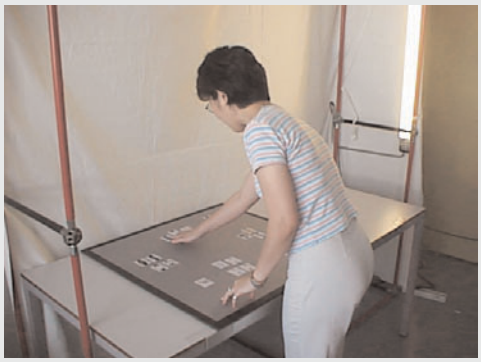


Figure 5.3 Subject organizing samples

Sub-task 1: Arranging

Procedure

At the start of the "Arranging" task subjects were handed an envelope containing all 25 product cards from one of the 4 product classes. They were then instructed to take all cards out of the envelope and lay them out in a meaningful way within the grey square of the board. The cards were not allowed to overlap. No additional constraints are given, which allows the subjects to freely express their impressions of the set of products as a whole. As such the task offers a degree of freedom and flexibility, similar to organizing a collection of products in a natural, non-experimental situation. The subjects are free to make one holistic arrangement, incorporating the whole set of products, or divide the set into as many parts as they like. The process is repeated for three other product classes, to determine whether the kind of product will have an effect on the resulting organization.

When subjects indicated they were satisfied with an arrangement, a picture of it was taken with the digital camera. Then the board with the arrangement was replaced with a new, blank board, after which the subjects were given a new envelope, containing the cards of the next product class. The order of the product classes was randomly balanced among the subjects.

Results

These findings are based on a total of 48 arrangements made by 12 senior students Industrial Design Engineering. None of them expressed any problems in performing this task. They all seemed to be quite comfortable with the large amount of freedom given to them. The fact that they were all senior design students, who through their education have acquired substantial experience with perceiving and assessing products, may have contributed to a large extent to this. In general the whole area of the grey square is used to lay out the cards, with the exception of one subject who only used the bottom half of the square.

A number of different styles of arranging can be distinguished. A rather striking observation is that the majority of the subjects already arrange the cards into distinct groups, without being explicitly instructed to do so. 'A meaningful way' seems to automatically incite them to making a classification, which is in line with the notion that classifying is a basic human activity. Moreover, the subjects who laid down distinct groups mostly produced grid-like compositions, in which the products are neatly arranged in rows and/or columns. Figure 5.4 shows the arrangements made by one of these subjects. They show clear-cut partitions of the total collection, with the distances between the cards acting only as dividers

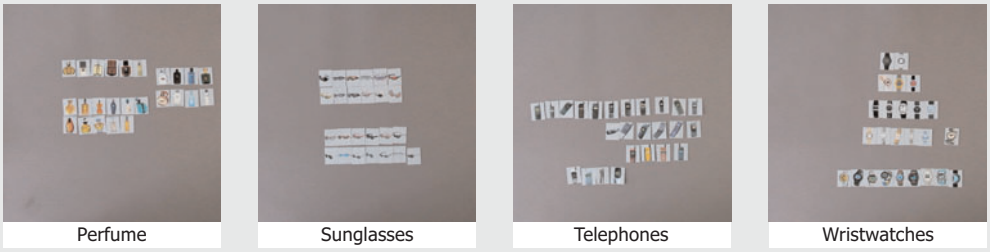


Figure 5.4 Arrangements made for the four product classes by subject 2. This subject laid down clearly distinct groups, in one or two horizontal rows.

to separate the groups, so that they can be clearly distinguished from each other. The ordering within the groups seems to be arbitrary.

One subject, in contrast, makes more 'holistic compositions', in which the borders between possible groups are not defined to the extent that they can be easily discriminated. Figure 5.5 depicts her arrangements, which seem to reflect that she has attached "meaningful" to the aesthetic value of the total image. Thus the distances between the samples are relevant in this case, with the samples that are considered similar placed closely together and the ones that are perceived as dissimilar, placed far from each other.

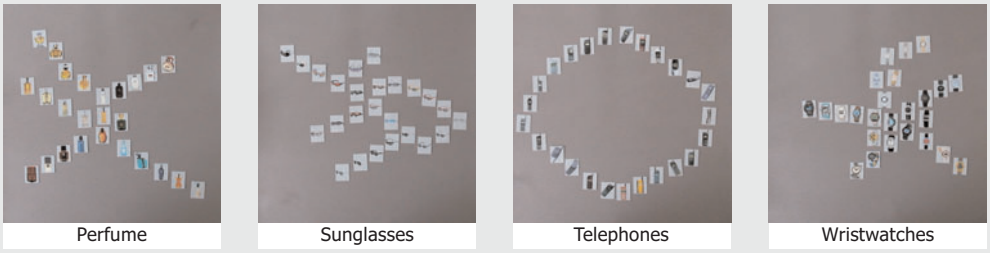


Figure 5.5 Arrangements made for the four product classes by subject 9. This subject laid down holistic compositions, using the entire area of the grey square.

The other five subjects use multiple approaches, making a holistic arrangement for one or two product classes, and a grouping for the other product classes. Figure 5.6 shows the arrangements of one of these subjects. A striking element in these arrangements is that some images are tilted at an angle, possibly for aesthetic reasons to articulate the overall composition.

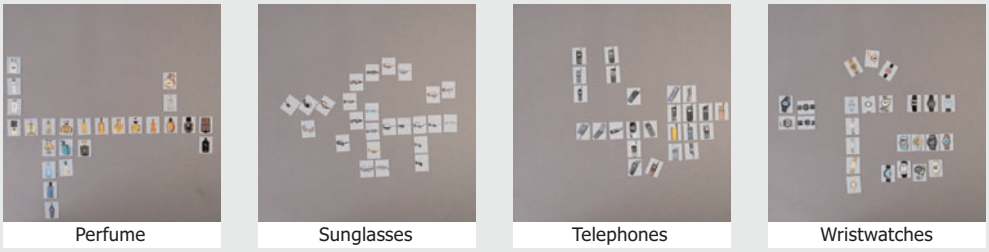


Figure 5.6 Arrangements made for the four product classes by subject 3. For "Sunglasses" and "Wristwatches" this subject uses tilt to achieve an aesthetic expression, maybe as an indication of a separate group.

Looking at the results at the level of each individual subject shows a high degree of consistency in the way in which the products are arranged: subjects clearly use the same style of arranging for each of the four product classes. The complete set of arrangements can be found in Appendix D: Arrangements.

In addition to these observations a few geometrical analyses were performed, to see whether a simple geometric criterion, such as the Euclidian distance between the image cards, might predict the groupings from their corresponding arrangements. The details of these analyses are not reported, however, since no strong, statistically significant patterns were found. Combining this with the large observed variety in arrangements, it was therefore concluded that this subtask in its present form does not provide enough relational information to build up a structured collection of design precedents. The instruction given to the subjects to 'lay these cards out in a meaningful way' appeared to elicit too much freedom, making a structured interpretation afterwards very difficult as well as subjective. However, the majority of arrangements (32 out of 48) consisted of partitions into discrete groups. Besides supporting the notion that classifying a collection of products into smaller classes is a spontaneous and natural activity for designers, this also suggests that more valuable information can be deducted from the results of the grouping task.

Subtask 2: Grouping

Procedure

In the second task "Grouping", the subjects were confronted with the results of the previous task. The board with the first arrangement was put back on the table and the subjects were instructed to rearrange the cards, if necessary, into clearly distinguishable groups. Although the subjects were allowed to let a group consist of only one card, they were urged to limit this as much as possible. After the subjects indicated they were finished, a picture was taken, the board removed and replaced with the board containing the arrangement of the next product class.

Results

These findings were based on a total of 48 groupings made by 12 subjects. The lay-outs were now abstracted to clean partitions by omitting the distances between the cards. Thus the resulting data describes only which products go into which group.

An important observation concerns the transition from the arrangements to the groupings. Already it has been noted that the majority of subjects spontaneously organized the samples into groups in the "Arranging" sub-task. Thus for these subjects the "Grouping" sub-task merely involved approving their previously made groupings, with only very limited fine-tuning taking place. For the other subjects, who made more holistic arrangements, making the groups simply consisted of dividing the total composition into smaller parts, with the resulting groups already clearly distinguishable in the larger picture. The "Grouping" sub-task to them thus merely involved pushing the cards that were considered similar away from the rest of the cards until they could be clearly distinguished as being separate groups. As an example figures 5.7 and 5.8 show the arrangement and the grouping for the product class "wristwatches" of the subject who made the most aesthetically composed arrangements.

A set of 25 cards can be partitioned in many ways. It is interesting to see whether the subjects made many or few groups, and if these were small or large.

Figure 5.7 Arrangement of wristwatches by subject 9

Figure 5.8 Grouping of wristwatches by subject 9

Coxon (1999) uses two variables to describe groupings: 1. the number of groups formed and 2. the relative size of the groups. The two variables can be combined to the height measure, which consists of the sum over all groups of the number of pairs in each of the groups. For a partitioning of n elements into m groups, where n_k is the number of elements in group k, height H is defined as:

$$H = \sum_{1}^{m} \frac{n_k(n_k - 1)}{2}$$

If a sorting is compact, comprising a small number of groups with each a large number of objects, the more pairs of objects there are and hence the greater the height. Thus the height becomes a measure of the "lumpiness" of an individual's or group's sorting. For example, the grouping of wristwatches by subject 9 as shown in figure 5.8, has a height of (7*6)/2 + (5*4)2 + (6*5)/2 + (4*3)/2 + (3*2)/2 = 55. In the extreme case where a subject puts all samples into one group, the height has its maximum value, in this case being (25*24)/2 = 300. On the other side of the scale, a grouping in which the number of groups equals the number of samples, has a height value of 0.

Table 5.1 shows the heights of all groupings made by the 12 subjects for the four product classes, with between brackets the number of groups within each grouping.

Table 5.1 Heights of groupings by subjects 1 to 12 on a scale of 0 to 300, with between brackets the number of groups

Subject	Perfume	Sunglasses	Telephones	Wristwatches
1	43 (7)	56 (6)	61 (5)	81 (5)
2	82 (4)	102 (3)	82 (4)	60 (6)
3	32 (9)	33 (8)	29 (8)	34 (7)
4	92 (3)	75 (4)	97 (4)	70 (4)
5	18 (12)	34 (8)	47 (6)	61 (5)
6	76 (5)	102 (3)	85 (4)	51 (6)
7	59 (6)	123 (4)	58 (5)	39 (8)
8	74 (4)	53 (6)	67 (4)	37 (7)
9	47 (6)	49 (7)	55 (5)	55 (5)
10	23 (11)	33 (8)	37 (8)	30 (8)
11	94 (4)	49 (6)	138 (3)	55 (5)
12	55 (5)	48 (6)	70 (4)	30 (8)

The majority of the subjects show a consistency across the four product classes. Those subjects who show a preference for rather lumpy groupings, do so for all classes, while the same goes for subjects who partition the collection into smaller groups. Between subjects a large variety is found, which suggests that a meaningful organization can be achieved at many levels of detail. Looking within the product classes shows a considerable distribution in height and number of groups, which indicates that each of the four collections lends itself to diverse groupings, without one partitioning being dominant.

Both the consistency within and the variety between subjects provide strong support for the development of a database which is built up and organized by a designer himself, instead of a database in which the organization is already in place. However, to determine whether the formed groups actually organize design knowledge regarding function, form and meaning as in the three typologies, a third subtask was performed, which involved the subjects giving names to the groups.

Subtask 3: Naming

Procedure

In the third task, "Naming", the boards with the cards were put on the table for the third time. The subjects were now instructed to give each group a name, write this name down on a yellow Post-It note and stick it close to the corresponding group. At this stage it was no longer allowed to make changes to the groupings. Again after completing the task, a picture was taken of the final result. On average the whole organizing task took about 30 minutes to complete.

Results

Table 5.2 shows the names given to the groups by all 12 subjects. To establish whether the names can be 'fit' into the three product typologies, each name was classified as either referring to functional features (function), perceptual features (form) or abstract features (meaning). In those cases where it was unclear to which category of features the name referred to, it was assigned to a fourth category (other). In the table the typeface expresses whether a name refers to ***function*** (bold italic), *form* (italics) or **meaning** (bold). Names which could not

unambiguously be assigned to one of these three categories are shown in standard typeface.

A large variety is found, ranging from names which describe the products' geometry, such as "straight", "angular" and "folding", to names which refer to a certain style, environment or user group associated with the products in the

Table 5.2 Names given to the groups by subjects 1 to 12

	Perfume	Sunglasses	Telephones	Wristwatches
S1	**stylish, sporty, classic, sea, chic, warm,** *organic*	**classic, sporty, safari,** *crude*, **feminine, extreme**	**average with taste, futuristic, colorful,** *blocky*, **high tech**	**plain, playful, sporty, arti, classic**
S2	**male, female, probably female**	*glasses with thick frames, glasses with thin frames,* **sports glasses**	*silver, color,* **standard**, *blue*	**swatch, kitsch**, **distinguished, kitsch but different, children,** ***waterproof***
S3	**warm,** *rigid,* **cool, expressive, chic, fresh, sweet,** *complex,* **baroque**	**pilot, new age, fashion, dark, child, light, active, quiet**	**easy, business, trendy, standard,** *elegant,* **scientific,** *compact, robust*	**playful, high tech, sporty,** 25 guilders, **classic, trendy, eccentric**
S4	*straight and angular, organic shapes,* ***pocket flask,***	**men summer glasses**, ugly glasses, **children's glasses, skiing glasses**	***buttons hidden, buttons visible color, buttons visible dark, folding***	**shiny, modern man/ women, sport, children**
S5	*both black,* **men water bottle**, *both white,* **women feminine**, *women angular yellow,* **men water, men polo, women light**, *women angular white, men reddish brown leather*, **women round, women sporty**	**pilot, cool sports, stylish,** *wire oval, red round,* **stylish sport, hyper sport**, *wire round*	great, **standard color**, ***extending, folding,*** *angular*, more than just making a call, **standard**	**kids, sport, men, women, design**
S6	**fresh, classic, male, exotic**	**hype,** *solid,* **sport**	**sporty, design,** ***practical,*** *compact*	**kids, basic, sport, fashion,** *elegant,* **impressive**

	Perfume	Sunglasses	Telephones	Wristwatches
S7	*decorative, brown,* **fast/modern,** *decorative vs. solid, decorative vs. a-symmetrical, a-symmetrical*	**mixture,** *metal frame, big edges,* **sporty/fast**	*inconspicuous/straight, inconspicuous/round,* ***without buttons,*** **technical,** ***shoving***	**sports, playful, swatch, noble, the architect, arty, sport vs. the artist, sports vs. normal**
S8	**kitsch, stylish, striking, feminine**	**outstanding, child, Michael Jackson, modern, sport, business**	**trendy, space, business, playful**	**feminine, diver,** *neutral,* **space, trendy, modern, child**
S9	**classic, noble,** *simple,* **feminine, kitsch,** *edgy*	*solid,* **flashy,** *elegant, fat,* **classic, playful, fast**	*elegant,* **playful, striking,** *edgy,* **design**	**sporty, design, happy, classic,** *solid*
S10	*black, white, light yellow, crème white, yellow and elongated, turquoise, green, black and red, yellow and round, blue, red*	*black,* **normal,** *red,* **tough,** *green,* **feminine, fast, sporty**	**common, Nokia,** *colorful,* **chic,** ***folding (black), folding (grey)****, silver,* **boring**	**child,** ***extensive,*** *neutral,* **boys, sporty, silver, fairground, plain**
S11	**not feminine,** *free form,* **old fashioned, link between both sexes**	**classic, trendy, not business, masculine, too macho,** ?	**distinct female character, too formal (still), no charisma**	*female form, too black,* **masculine, not business, masculine with female potential**
S12	*simple,* **stylish, feminine, kitsch, outstanding**	**pilot's glasses,** *standard,* **outdated, happy, sporty**	**boring, trendy,** ***ingenious,*** tried to make nice but unsuccessful	**neat/business-male, neat-business-female, super sporty & trendy, outdated childish, sporty, chic, festive**

group, such as "sporty", "classic" or "pilot". Some subjects sometimes seem to use a kind of hierarchy, with one central topic divided into multiple subtopics, such as "cool sports"/"stylish sport"/"hyper sport" or "men water"/"men polo".

The labels "men", "women", "feminine", "masculine", "male" and "female" are often used, self-standing or in combination with another adjective. This

suggests that gender is an important factor in the classification, although this might to a large extent be induced by the specific character of the product classes "Perfume", "Sunglasses" and "Wristwatches". The fact that the product class "Telephones" elicits hardly any references to gender can be explained by considering that this is a class of products which has only recently come to a full development, having no models specially designed for men or women on the market yet. "Sport" or "sporty" is also often attached to a group, especially in the product classes "sunglasses" and "wristwatches". Again this is not surprising, considering the character and intended use of both kinds of products.

Table 5.3 shows for each of the four product classes the number of names referring to either function, form, meaning or other.

Table 5.3 Number of names referring to function, form, meaning or other.

	Perfume	Sunglasses	Telephones	Wristwatches	Σ
function	1	0	12	2	15
form	26	16	14	7	63
meaning	41	46	30	64	181
other	0	2	3	1	6
Σ	68	64	59	74	265

Only 6 (e.g. "ugly glasses", "25 guilders) out of a total of 265 names could not be assigned to one of the three typologies. This low frequency of names that are unimportant and irrelevant to the design process, clearly supports the notion that together the three typologies cover the total range of features that designers spontaneously use to classify products. No 'meta'-names, such as "the rest" or "other" were given, which is again an indication that the subjects felt comfortable giving meaningful names to all groups. The low number of names referring to "function" is no surprise, since all 25 samples in each product class were designed to fulfill the same primary function. The high number of names referring to "meaning" might be attributed to the fact that all subjects were design students, who through their education have been trained to evaluate products in this way.

Finally, table 5.4 shows the number of typologies used by the subjects within each grouping.

Table 5.4 Number of typologies used within each grouping

	Perfume	Sunglasses	Telephones	Wristwatches
S1	1	2	2	1
S2	1	2	2	2
S3	2	1	2	1
S4	2	2	1	1
S5	2	2	3	1
S6	1	2	3	2
S7	2	2	3	1
S8	1	1	1	2
S9	2	2	2	2
S10	1	2	3	3
S11	2	1	1	2
S12	2	2	2	1

Clearly in the majority of cases multiple typologies are used simultaneously when organizing the product samples. Thus the subjects seem to be comfortable with using more than one criterion at the same time.

Conclusions

Perhaps the most easily overlooked result is the observation that all the activities performed in the three sub-tasks seemed to be natural to the subjects. All subjects acted comfortably in the situations presented to them. This perceived naturalness of arranging, grouping and naming products might seem a rather trivial observation at first, since classification has been already described as a fundamental and purposeful human activity. People are capable of comparing multiple items on multiple dimensions, organizing them accordingly into groups in which the items share certain characteristics and subsequently attaching textual labels to these groups. Morel (2000) showed that people in a free classification task spontaneously sort products into basic-level categories. However, the present study involved classification on different levels, since the basic-level was already presented in the distinction of the four product classes. Classifications on sub-ordinate and super-ordinate level should impose a much greater cognitive load on the subject than a basic-level classification. The observation that the subjects did not seem to perceive it as such, thus supports the idea that

designers are used to organize knowledge about products on other levels than the common basic level.

The extra freedom given in the arranging task, in which grouping was not explicitly required, did not lead to readily interpreted information above that obtained in the grouping task. In a majority of the arrangements the products were already spontaneously organized into distinct groups, further supporting the notion that classifying is indeed a natural activity. In those cases in which holistic compositions were made, the focus seemed to be more on the aesthetic appeal of the overall image than on the positions of the products relative to each other. However, breaking down such a composition consisted mainly of dividing the total image into smaller chunks without doing much additional organization, the groups which were subsequently formed thus already being distinguishable in the composition. Too much freedom in the task could even have an adverse effect by allowing the designer to focus on other aspects than the similarities and differences between the products.

The specific characteristics of a product class, such as telephones or sunglasses, did not seem to influence the organizing behavior of the subjects. The way(s) in which they arranged, grouped and named the products appeared consistent across all four product classes. The fact that the names given to the groups could be easily attached to one of the three product typologies suggests that directing the classification process towards these typologies might enhance their formation.

5.3 Experiment: the influence of a design brief

Designing a product normally doesn't start from scratch. From the beginning the development of new product ideas and concepts is guided by a set of requirements, intentions and wishes, that state the needs the product should fulfill, who the intended consumers are, in what kind of environment or lifestyle it has to fit etc. Usually these requirements and wishes are put down in textual statements, which together make up the design brief, that provides the designer with a starting point to visualize mentally or on paper the context of the product to be designed.

It is the goal of the designer to translate these statements into a physical product appearance. To identify how this translation has been achieved in products currently on the market, the designer might organize these to the degree to which they represent the features which were stated in the design brief. In accordance with the previously developed ideas on concepts and product types, a design brief can be regarded as a prescriptive framework, containing cues which can guide the selection of relevant product types. It typically states the external goals a product has to fulfill and not its internal structure, since the latter is, of course, that which has to be designed. Thus the cues presented in the design brief mostly will refer to the future product's abstract features.

For example, if the design brief states that the product to be designed should express a 'high-tech' and 'stylish' character, then classifying a set of design precedents to the extent to which they reflect 'high-tech' and 'stylish', would bring to the surface those characteristics of the products' appearances which are responsible for them to be perceived as such. In contrast, when no brief is given, the products' perceptual features seem to be the most natural candidates to direct the organization process, since they don't need any additional processing of design knowledge to be identified.

Does a design brief then lead to more similar organizations, resulting in groupings that 'fit' the specifications of the brief as opposed to the 'natural' groupings based on the product images alone? To answer this question we compared subjects doing the organizing task with or without a given brief. Analyzing the results concentrated on the differences between both conditions, especially regarding the content of the made groupings.

Procedure

12 senior Industrial Design Engineering students, six male and six female, participated as subjects. The total group was randomly split into 2 groups of three male and three female, of which one was labeled as the "Context" group and the other as the "No context" group. The subjects, who performed the task individually, were paid 5 euro for their participation, which took approximately 30 minutes

It was decided to use the same situation as in the experiment of chapter 4, being the design of a mobile telephone for a female executive. The experiences with this situation given to the subjects in this experiment showed it to be well-defined in its goals and requirements, as well as workable and challenging for senior design students. Before starting the organizing task, the 6 subjects in the "Context" group were asked to read the following brief, which was given to them on paper:

Please read the following description of a fictitious design situation carefully.

You are working as a free-lance designer. You have been contacted by Hands-On, a recently started manufacturer of telephones, who wants to put its first product on the market within one year. In order to increase the chances of a successful introduction, the existing market has been thoroughly analyzed. Extensive marketing research has led to the conclusion that the ever-increasing number of female executives is a target group that is insufficiently served with the telephones which are currently on the market. Based on this, the management of Hands-On decided to work on a line of products, specifically for this target group, that has to clearly distinguish itself from the current market supply.

Your task is to design a mobile telephone, specifically for a female executive. Tomorrow you have a meeting with the management of Hands-On, in which you will have to present your first concept. You will have to provide the members of the management team with a realistic impression of the generated concept regarding form and color, as well as its use by the target group.

You are asked to place yourself into this situation for the complete duration of the experiment. This description will always be available to you, so please refer to it when considered necessary.

During the actual experiment the subjects in the "Context" group were occasionally reminded of the brief, which was available for them to read during the entire course of the experiment. Only after finishing the organizing task were they told that, since this was the end of the experiment, they were not required to actually design a mobile telephone. The subjects in the "No context" group did not receive any additional instructions before starting the task. At the beginning of each of the three sub-tasks, a short procedural instruction was given to all subjects.

From the context described in the brief, four different product classes were selected as being relevant to the situation at hand. The class of "telephones" was used because it represents the product class of the object to be designed. Reviewing instances from this class would provide the designer with functional and perceptual product features relevant to his design. The classes of "wristwatches", "sunglasses" and "perfume" were chosen because they were considered to be among the kind of products with which a female executive would surround herself. Thus evaluating these products would provide a designer with design knowledge regarding possible perceptual and abstract product features.

Results

Arrangements

The general findings from the "Arranging" sub-task have already been presented in section 5.2. Extensive exploratory analysis has been undertaken to detect differences between both groups of subjects. For example, the Euclidean distances between each of the 25 products cards were used in a Multi-Dimensional Scaling (MDS) analysis to determine whether the arrangements of the subjects in a group were more similar to each other than to the arrangements of the subjects in the other group. In the extreme case where the subjects in one group would place all cards into completely compact arrangements, while the subjects in the other group would make arrangements with all cards evenly distributed across the grey square, a MDS-display of all subjects would show the two groups as two clearly separate clusters. Figures 5.9 through 5.12 show the resulting MDS-display for each product class, with the subjects in the "No context" group depicted as the dark circles and the subjects in the "Context" group in the light circles.

None of the displays shows a clear distribution of the subjects into two separate groups. Thus the distances between the products provided no indication for a possible effect of the given design brief on the arrangements. They are also not suitable for deriving the groupings. Although the arrangements clearly hint at the groupings that are subsequently produced, the definite contours of these groupings cannot unambiguously be deduced from them.

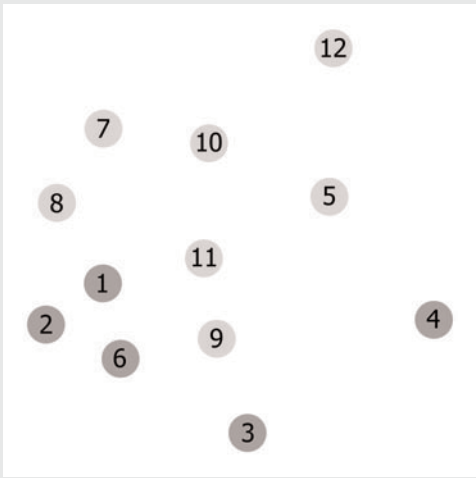


Figure 5.9 MDS-display of all subjects for "Perfume"

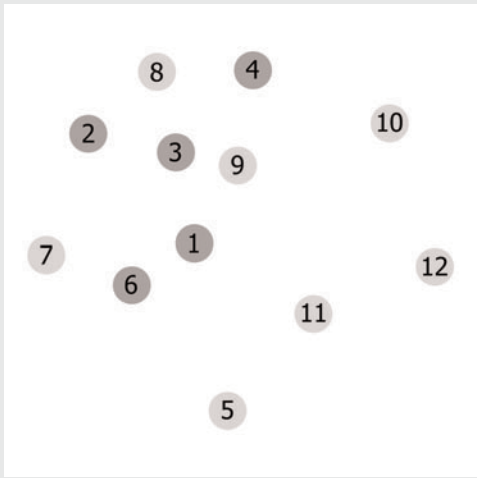


Figure 5.10 MDS-display of all subjects for "Sunglasses"

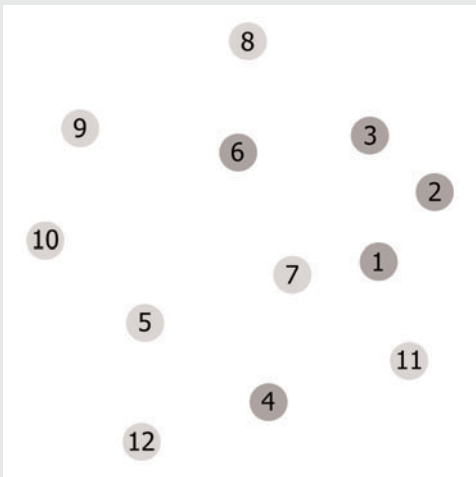


Figure 5.11 MDS-display of all subjects for "Telephones"

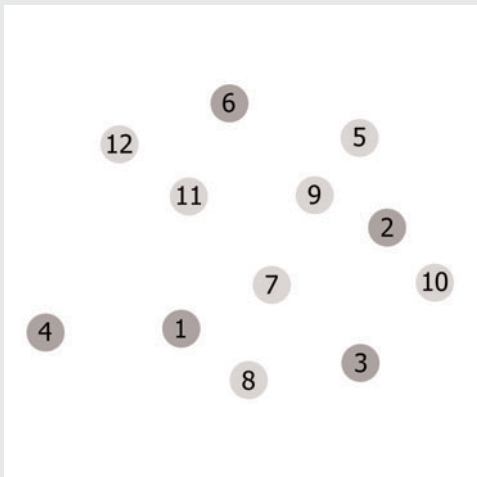


Figure 5.12 MDS-display of all subjects for "Wristwatches"

Groupings

Table 5.5 shows the heights of the groupings made by the subjects in both conditions for the four product classes. A first inspection of these results shows them to be quite similar for both conditions. To determine whether any of the differences is significant, a paired t-test was performed, the results of which are shown in table 5.6

Table 5.5 Heights "Context" group vs. "No context" group

		Mean	Std. Dev.	Minimum	Maximum
Perfume	*Context*	58.67	24.11	23	94
	No context	57.17	30.18	18	92
Sunglasses	*Context*	59.17	32.03	30	123
	No context	67.00	30.80	33	102
Telephones	*Context*	70.83	34.89	37	139
	No context	67.00	25.51	29	97
Wristwatches	*Context*	41.00	11.44	30	55
	No context	56.33	12.06	35	70

Table 5.6 Paired t-test on heights "Context" group vs. "No context" group

	Mean Diff.	t-Value	P-Value
Perfume	-1.500	-.077	.942
Sunglasses	7.833	.399	.706
Telephones	-3.833	.185	.861
Wristwatches	15.333	1.842	.125

No significant differences were found, which indicates that the subjects in both conditions showed a similar grouping behavior in terms of the number and size of the groups they made. Thus the specifications of the design brief did not lead to a more fine-grained grouping.

Cluster analysis

To determine whether there are any differences with respect to content in the groupings made by the subjects in both groups, a cluster analysis was performed. In a cluster analysis a large amount of data is reduced into smaller subgroups. These subgroups, called clusters, should exhibit high internal (within-cluster) homogeneity and high external (between-cluster) heterogeneity. As a clustering algorithm the average linking method was selected, a hierarchical procedure in which the cluster criterion is the average distance from all objects in one cluster to all objects in another. Similarity between objects was measured in this case by the number of times a pair of products was put into the same group. For example, if telephones 5 and 11 were put into one group by all 6 subjects of the "Context" group, the corresponding cell in the similarity matrix for this condition

would contain a 6. Thus 8 similarity matrices were constructed and each served as input for a cluster analysis.

The results of a cluster analysis are usually represented in a so-called dendrogram, in which each object is arrayed on one axis, while the other axis portrays the step in the hierarchical procedure. A dendrogram thus shows graphically how the clusters are combined at each step of the clustering procedure until all are contained in a single cluster. From these dendrograms the final number of clusters now has to be determined for each case. A weakness of cluster analysis, however, is that there is no standard, objective selection procedure for this. While there have been developed a number of guidelines, these are all rather ad-hoc, involving fairly complex procedures. One of the most popular of these so-called 'stopping rules' looks at steps in the clustering were the distance between clusters makes a sudden jump. For the average linking method this distance is the agglomeration coefficient, which is the squared Euclidian distance between the two clusters being combined. If these two clusters are very different from each other, combining them into one cluster results in a large coefficient or a large percentage change in the coefficient. Thus the prior cluster solution is selected, since in this solution the within-cluster similarity is considerably higher. In a dendrogram a long horizontal line indicates that this particular cluster is hard to combine with any of the others. Table 5.7 shows the number of clusters that resulted from applying this stopping rule on the groupings.

Table 5.7 Number of clusters for both conditions

	Product	No context
Perfume	7	4
Sunglasses	5	4
Telephones	3	4
Wristwatches	4	3

As an illustration, figure 5.13 shows the resulting dendrogram for the "No context" group for the product class "perfume", with the final clusters indicated in bold lines. An in-depth comparison of the resulting clusters for each of the product classes is presented in the next paragraph. All dendrograms can be found in Appendix E: Dendrograms.

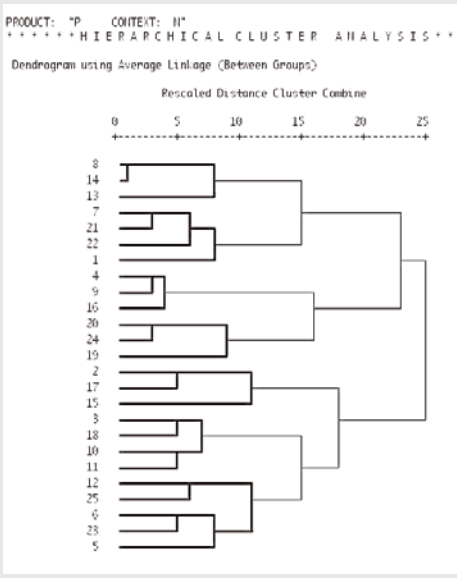


Figure 5.13 Dendrogram for Hierarchical Cluster Analysis. Average linking, Perfume, No context

Interpretation of the clusters

For each product class the clusters made in the two conditions are displayed side-by-side, to make visual comparison possible. The clusters, and the products in them, are ordered in such a way, that the differences between both conditions are as little as possible. For each cluster, a few of the names which have been attached to the products, are listed. Again, the difference in typestyle indicates whether a name refers to ***function***, *form* or **meaning**.

No Context

Cluster P-NC-1
Female, *Straight and angular*, **Exotic**

Cluster P-NC-2
Classic, Female, *Expressive*

Cluster P-NC-3
Fresh, Sporty, Female

Context

Cluster P-C-1
Non-feminine, Stylish, Decorative

Cluster P-C-2
Kitsch, Old-fashioned, *Yellow and round*

Cluster P-C-3
Stylish, Modern, *Simple*

Cluster P-NC-4
Fresh, *Organic shapes*, **Sea**

Cluster P-C-4
Feminine, *Free-form, A-symmetrical*

Cluster P-NC-5
Male, Stylish, *Strict*

Cluster P-NC-6
Warm, *Male reddish brown leather*, **Exotic**

Cluster P-NC-7
Male, Chic, *Pocket flask*

Although at first sight the difference in the number of clusters seems to be quite large, closer inspection shows that through a few simple mutations the difference can be largely reduced. By merging cluster P-NC-1 and P-NC-5 a large part of cluster P-C-1 is covered. Clusters P-NC-2 and P-C-2 are identical in appearance, and also show a large similarity in the meaning of the attached labels. Cluster P-C-4 can be almost completely formed by merging clusters P-NC-4 and P-NC-6. Looking at the Context condition there appears to be a division between non-feminine products, as represented by cluster P-C-1, and feminine products, as represented by the other three clusters. However, a similar division can also be made for the No Context condition by grouping clusters P-NC-1, P-NC-2 and P-NC-3 (feminine) and clusters P-NC-4, P-NC-5, P-NC-6 and P-NC-7 (masculine). Both conditions show a preference for names that refer to the clusters' meanings, as reflected by the products' abstract features.

No Context

Cluster S-NC-1
Men's sunglasses, *Thin frame*, **Classic**

Cluster S-NC-2
Sporty, Sports glasses, Hype

Cluster S-NC-3
Sports glasses, Sports, Skiing glasses

Cluster S-NC-4
Fashion, Hype, *Thick frame*

Cluster S-NC-5
Solid, Thick frame

Context

Cluster S-C-1
Business, Standard, *Metal frame*

Cluster S-C-2
Trendy, Sporty, Flashy

Cluster S-C-3
Sporty, Fast, *Elegant*

Cluster S-C-4
Child, Happy, Non-business

Again the differences in the formed clusters are small between conditions. Cluster S-NC-1 is almost similar to cluster S-C-1, the same goes for clusters S-NC-2 and S-C-2. Cluster S-NCC-3 can completely be found in cluster S-C-3, while cluster S-NC-4 is almost completely embedded in cluster S-C-4. Finally, cluster S-NC-5 can be fully found in cluster S-NC-4.

Looking at the textual descriptions shows a preference for abstract features as Sporty and Flashy. The label Business in the Context condition might be induced by the given design brief.

No Context

Cluster T-NC-1

Standard, ***Buttons visible dark***, **Practical**

Cluster T-NC-2

Compact, **High tech**, ***Folding***

Cluster T-NC-3

Colorful, Sporty, *Color*

Context

Cluster T-C-1

Boring, No appeal, Business

Cluster T-C-2

Trendy, *Round, Elegant*

Cluster T-C-3Cluster T-NC-3

Ingenious, ***Folding***, **No appeal**

Cluster T-C-4

Playful, Colorful

The No-Context condition show one large cluster T-NC-2, which to a large extent can also be created by merging clusters T-C-1 and T-C-2. Cluster T-NC-1 and T-C-1 appear to represent the standard, non-interesting products. Cluster T-C-2, with its descriptions like Trendy and Elegant might be formed as a consequence of the design brief, grouping together telephones which would fit a female executive. Clusters T-NC-2 and T-C-3 are most likely formed because of similarity in physical construction, as indicated by a term as Folding. Finally, clusters T-NC-3 and T-C-4 are clearly based on the fact that these telephones distinct themselves through their colorful appearances from the other examples.

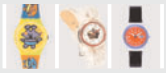
No Context

Cluster W-NC-1

Classical, *Shiny*, **Ladies**

Cluster W-NC-2

Modern man/woman, Basic, Trendy



Cluster W-NC-3

Children, Playful, Kids

Cluster W-NC-4

Sports, ***Waterproof***, **High tech**

Context

Cluster W-C-1

Feminine, Classical, *Female shape*

Cluster W-C-2

Sporty, Masculine, Space

Cluster W-C-3

Neutral, Modern, *Strict*

Cluster W-C-1 can be fully embedded in cluster W-NC-1. The two remaining samples of cluster W-NC-1 can then be merged with cluster W-NC-2 to equalize cluster W-C-2. In a similar way, merging clusters W-NC-3 and W-NC-4 forms cluster W-C-3.

Looking at the Context condition reveals a subdivision into a Feminine group (W-C-1), a Masculine group (W-C-2), and a Neutral group (W-C-3). Again, this distinction might be affected by the design brief. The No Context condition shows a more general subdivision into a Classical, Modern, Children and a Sports group.

Overall, this comparison makes clear that the groupings resulting from both conditions are quite similar regarding content as well. While there might be substantial differences between individual subjects within each condition, as described and discussed in section 5.2, these differences disappear when the individual groupings are clustered. Thus on a more general level the behavior of the subjects seems to be unaffected by the additional factor of the design brief.

Table 5.8 Number of names referring to function, form, meaning or other for the "Context" group and the "No context" group.

		Function	Form	Meaning	Other	Σ
Perfume	No context	1	10	26	0	37
	Context	0	16	15	0	31
Sunglasses	No context	0	7	23	1	31
	Context	0	9	23	1	33
Telephones	No context	7	9	14	2	32
	Context	5	5	16	1	27
Wristwatches	No context	1	1	30	1	33
	Context	1	6	30	0	37

Naming

Finally, Table 5.8 shows the number of names referring to each of the three typologies for both conditions.

The numbers do not suggests significant differences between both conditions. Again "meaning" has the highest number of names attached to it, followed by "form" and 'function".

Conclusions

The fact that a given context by means of a design brief did not result in different arrangements, groupings and names is somewhat in contrast to what was expected. Two factors may have contributed to this. First, placing themselves into the fictitious situation for the whole duration of the experiment might have been too much of an effort for the subjects. When confronted with a set of products, the specifications of the design brief might have easily become 'overruled' by the specific features of the products themselves, which were much more prominently present during the experiment.

Second, selecting the products that were to be organized, was not a task in the experiment. Had the organizing task been preceded by a selection task in which the subjects had to pick the products themselves from a larger collection, subjects in the "Context" group might have exclusively chosen products which would have had a direct relevance for the given situation. However, although they were allowed to do so, not one subject in the "Context" group divided the 25 products into two groups, with all products relevant to the design of a mobile

telephone for a female executive into one group, and all the other products into the other.

5.4 Discussion

The main objective of this chapter was to provide input for the development of the proposed visual database of design precedents. The results will therefore now be reviewed in light of this development. What implications do the identified organization strategies of designers have for the design of the database, how suitable is the organizing task as a means of indexing products into the database, and to what extent will the effects of product class and design brief influence its design?

The results of the present study demonstrate the feasibility of a database which may have a starting set of example products, but is essentially built up, organized and extended by a designer himself. The apparent naturalness with which all subjects performed the organizing task, even though it did concern arranging, grouping and naming products on levels other than basic, indicates that designers are capable of creating meaningful organizations which would form the core of the database.

Indexing products into the database then becomes an important functionality, which has to be fully supported by the database's interface. Comparing the results from the three sub-tasks suggests that a two-step indexing procedure, consisting of a grouping task and a naming task, is the most fruitful approach for entering data into the database. Following this procedure products get indexed simultaneously by spatially organizing them into groups. To guide the grouping, criteria from the three typologies should be provided. Thus relationships between products regarding these criteria get established and stored into the database. It is these relationships, and not the characteristics of the individual products, which are the actual content and strength of the database.

The large variety in arrangements, groupings and names provides an additional argument in favor of a database that can be tailored to the specific needs of a designer. The fact that the names given to the groups could be easily

attached to one of the three product typologies suggests that directing the classification process towards these typologies might enhance their formation. The specific characteristics of a product class, such as telephones or sunglasses, did not seem to influence the organizing behavior of the subjects. The way(s) in which the designers arranged, grouped and named the products appeared consistent across all four product classes. This suggests that this approach will hold true for a large variety of products.

The fact that the design brief had no apparent effect on the groupings indicates that the subjects where not influenced by a specific context. They appeared to base their decisions regarding grouping and naming primarily on the characteristics of the products. Thus the indexing of products into the database can be done independently from a specific design situation. The resulting product types are by nature generally applicable, which implies that the database can be used in any design situation, without much additional reorganization of its contents having to take place. The effects of a specific design situation would express themselves not in the formation of these product types, but more in the queries that would induce their retrieval from the database. Having the proposed typological framework in place as a template to direct this retrieval process would boost the applicability of the database in a wide variety of situations.

In the next chapter…

the actual design of the proposed visual database is described. A review of design support systems, which make use of existing products, is first presented, followed by listing a number of design criteria, which guided the development of the user interface of the database. Taking these criteria into account, a new method of interacting with large information structures, called MDS-Interactive, was developed. A number of prototypes were built to demonstrate and evaluate the new method. With a few modifications MDS-Interactive then provided the basis for the visual database, which was named ProductWorld. The design of ProductWorld is presented, followed by an evaluation of its use in an educational setting.