Chapter 11

Prior Experience and Intuitive Use: Image Schemas in User Centred Design

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11.1 Inclusive Design and Intuitive Use

Inclusive design is concerned with the "design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design" (BSI, 2005). What does "the widest range of abilities" of people refer to? Usually, users' abilities are categorized into sensory, motor, and cognitive abilities (Keates and Clarkson, 2003).

Supporting sensory abilities means enhancing the perceptibility of user interface elements (*e.g.* enhancing contrast and font size). Supporting motor abilities means enhancing operability of controls (*e.g.* changing their size and spacing or the force needed to operate them). Supporting cognitive abilities means enhancing thinking and communication (Clarkson *et al.*, 2007) and is often referred to as enhancing 'intuitive use' (*e.g.* Story, 1998). However, it often is not clear what intuitive use is and how designers can design for it (Blackler, 2006).

Intuitive use is defined as the *users' subconscious application of prior knowledge that leads to effective interaction* with a product (Hurtienne and Blessing, 2007; Naumann *et al.*, 2007). When knowledge is so deeply rooted in memory that it is applied automatically and subconsciously, it means that interaction takes place with a minimum of mental effort.

What prior knowledge on the part of users can designers of interactive systems focus on? Different sources of knowledge are possible. These sources can be roughly classified along a continuum. The first and lowest level of the continuum consists of *innate* knowledge that is 'acquired' through the activation of genes or during the prenatal stage of development. Generally, this is what reflexes or instinctive behaviour draw upon. Purists will see this as the only valid level of knowledge when talking about intuitive interaction, because it assures universal applicability and subconscious processing.

The *sensorimotor* level consists of general knowledge, which is acquired very early in childhood and is from then on used continuously through interaction with the world. Children learn for example to differentiate faces; they learn about gravitation; they build up concepts of speed and animation. Scientific notions like affordances (Gibson, 1979), gestalt laws (*e.g.* Koffka, 1935), and image schemas (Johnson, 1987) – which are the topic of this paper – reside at this level of knowledge.

The next level is about knowledge specific to the *culture* in which an individual lives. This knowledge can vary considerably between cultures and may influence how people approach technology. It touches, for instance, the realm of values (*e.g.* what constitutes a taboo), the styles of visual communication (*cf.* Japanese manga vs. American comics), but also concerns knowledge about daily matters like the usual means of transportation (*e.g.* busses, trains, or bicycles) or the prevalent form of energy supply (*e.g.* by a public power line or by burning wood for heating).

The most specific level of knowledge is *expertise*, *i.e.* specialist knowledge acquired in one's profession, for example as a mechanical engineer, an air traffic controller, or a physician; and in hobbies (*e.g.* modelling, online-gaming, or serving as a fire-fighter).

Across the sensorimotor, culture, and expertise levels of knowledge, knowledge about *tools* can be distinguished (Hurtienne and Blessing, 2007). Tool knowledge is an important reference when designing user interface metaphors. The desktop metaphor, for instance, is thought to tap the knowledge of a typical office environment including folders, documents, and a wastebasket.

The application of knowledge may be subconscious from the beginning on (as with reflexes) or may have become subconscious due to very frequent exposure and reaction to stimuli in the environment: the more frequent the encoding and retrieval was in the past, the more likely it is that memorised knowledge is applied automatically and subconsciously. Knowledge at the expertise level is acquired relatively late in life and is (over the life span) not as frequently used as knowledge from the culture or sensorimotor level. Knowledge from the lower levels of the continuum is therefore more likely than knowledge from the upper levels to be applied automatically. If the subconscious application of knowledge is a precondition for intuitive use, it will be more likely to see intuitive interaction involving knowledge at the lower levels of the knowledge continuum. Also, the further down in the continuum, the larger and more heterogeneous the user groups that can be reached. Designs aiming at the lower levels of the continuum therefore will be more inclusive.

In the remainder of this article image schemas, rooted in the sensorimotor level of knowledge, are presented as a framework for user-interface design. Some early applications of image schemas are discussed.

11.2 Image Schema Theory

According to Johnson, one 'father' of image schema theory, image schemas are abstract representations of recurring dynamic patterns of bodily interactions that structure the way we understand the world (Johnson, 1987). The UP-DOWN image schema, for example, forms the basis of "thousands of perceptions and activities we experience every day, such as perceiving a tree, our felt sense of standing upright, the activity of climbing stairs, forming a mental image of a flagpole, measuring the children's heights, and experiencing the level of water rising in the bathtub" (Johnson, 1987). The UP-DOWN image schema is the abstract structure of all these experiences. It is neither a concrete mental image nor a meaningless abstract symbol. Depending on the author, about 30 to 40 of such image schemas are distinguished. Table 11.1 show the image schemas that were used in the studies referred to and described in this paper.

Table 11.1. List of image schemas used in the studies referred to and described in this paper

Group	Image Schemas
BASIC	OBJECT, SUBSTANCE
SPACE	CENTER-PERIPHERY, CONTACT, FRONT-BACK, LEFT-RIGHT, NEAR-FAR, PATH, ROTATION, SCALE, UP-DOWN
CONTAINMENT	CONTAINER, CONTENT, FULL-EMPTY, IN-OUT, SURFACE
MULTIPLICITY	COLLECTION, COUNT-MASS, LINKAGE, MATCHING, MERGING, PART-WHOLE, SPLITTING
PROCESS	CYCLE, ITERATION
FORCE	ATTRACTION, BALANCE, BLOCKAGE, COMPULSION, COUNTERFORCE, DIVERSION, ENABLEMENT, MOMENTUM, RESISTANCE, RESTRAINT REMOVAL
ATTRIBUTE	BIG-SMALL, DARK-BRIGHT, HEAVY-LIGHT, STRAIGHT, STRONG-WEAK, WARM-COLD

Not only SPACE image schemas like UP-DOWN are found in this table, but also image schemas for CONTAINMENT, MULTIPLICITY, PROCESS and FORCE. The BASIC image schemas OBJECT and SUBSTANCE underlie much of human abstract reasoning. For example, ideas are conceptualized as concrete OBJECTS expressed in "I can't *grasp* the idea" or "Sally *carries* that idea *around* with her all the time". ATTRIBUTE image schemas are less rich in structure and denote common properties of objects.

This transfer of image schemas from physical interaction with the world to the thinking about abstract, non-physical entities is called *metaphorical extension* of the image schema. Metaphorical extensions are often grounded in bodily experience that is universally accessible to all people. For example, experiencing the level of liquid rising in a container when more liquid is added or seeing a pile of paper shrink when sheets are taken away leads to the metaphorical extension

MORE IS UP, LESS IS DOWN of the image schema UP-DOWN. This correlation of amount and verticality subsequently is generalized to non-physical abstract entities like money or age, for example in expressions like "My income *rose* last year", "Rents are going *up*", or "He is *under*age". Other metaphorical extensions of the UP-DOWN image schema are GOOD IS UP, BAD IS DOWN ("We hit a *peak* last year, but it's been *down*hill ever since"), HAPPY IS UP, SAD IS DOWN ("I'm feeling *up*", "He is really *down* these days"), or HIGH STATUS IS UP, LOW STATUS IS DOWN ("She'll *rise* to the top", "He's at the *bottom* of the social hierarchy"). These and other metaphorical extensions of image schemas have also been validated outside linguistics, for example in gesture research, psychology, and computational neuroscience (for an overview see Hampe, 2005), and also in user-interface design (Hurtienne and Blessing, 2007).

11.3 Image Schemas in User-Centred Design

Image schemas contribute to intuitive interaction via the principles of spatial and abstract mappings. *Spatial mappings* can occur between user interface controls and expected effects in the real world or between displays and controls. Turning the steering wheel of a car to the LEFT will result in a leftwards motion, turning it to the RIGHT results in a rightward motion of the car. *Abstract mappings* occur between user interface elements and abstract concepts via metaphorical extensions. Examples are using UP-DOWN in a vertical slider for controlling the intensity of the speaker volume (MORE IS UP) or rating the attractiveness of a new car (GOOD IS UP). This use of image schemas for representing abstract concepts is one of the major promises for user-interface design, because, in the mind of users, they subconsciously tie the location, movement and appearance of UI elements to their functionality.

How can a designer use image schemas when designing intuitive interaction? Two ways are possible: (1) Designers can apply image schemas during the analysis and design phases of a user-centred design process. A proof-of-concept case study has been conducted to show the applicability and usefulness of image schemas for user-interface design. (2) Designers can exploit image schema uses that are already documented. A database of image schemas and metaphorical mappings has been built as a first step to support this. Both approaches are discussed in the following sections.

11.3.1 Image Schemas in a User-centred Design Process

The user-centred design process, according to ISO 13407, comprises four core activities: (1) Understand and specify the context of use, (2) Specify the user and organisational requirements, (3) Produce design solutions and (4) Evaluate designs against requirements. A proof-of-concept study was set up that undertook the redesign of the invoice verification and posting procedure in the accounting department of a German beverage company. The design process, the methodology and the outcome of the study are discussed within this section.

Activity 1: Understanding and Specifying the Context of Use

In this first activity, and according to the ISO standard, each of the following were analysed: users, their tasks, the existing technology, and the socio-technical context in which they interact.

Three users were interviewed and observed at their workplace. During work analysis users were asked to think aloud and their utterances were recorded using a voice recorder. The users were between 42 and 55 years old and had between 2 and 17 years of experience with the task. The workplace of each user has two screens. The left screen contains an SAP R/3 application displaying invoice data. The right screen holds a digitised image of the original paper invoice, a list of contact persons and a tool for writing and forwarding notes.

The task of invoice verification and posting is not overly complex. The enterprise purchases goods or services and receives an invoice from the supplier in return. The user's task starts with comparing the data in the SAP R/3 application with the original invoice image and making sure all information is complete and according to legal requirements. After that prices and quantities are checked against orders and receipts of goods. If everything is correct, the users are enabled to post the invoice. If information is missing, inappropriate or unclear, users forward the document to the appropriate operating department. There the data or authorisations they need to finally post the invoice are provided.

For the specification of the context of use image schemas were extracted from (1) single work steps, (2) the user interface of the current system, (3) the user's interaction with the system, and (4) the user's mental model. The latter was achieved by transcribing and analysing the language of the users talking about their work. Image schemas could indeed be used to describe most aspects of the context of use. For example, one of the first steps the users undertake is to check whether the data of the paper invoice was digitised correctly. In order to do so, users compare the digitised data with the original invoice image. This step is linked to the image schema MATCHING because the two different sets of data have to fit together – they have to match. The user's language supports this image schema (German): "Dann muss man halt alles *abgleichen*, […] ob das alles *stimmt*". ("Then one just has to *compare* everything, […] to see if everything *matches*").

Activity 2: Requirements Specification

Requirements were specified with a focus on (1) requirements resulting from business and financial objectives and (2) user requirements such as the allocation of users' tasks, user-interface design, communication and co-operation between users. The requirements were directly derived from the results of the context-of-use analysis. The basis for formulating the requirements was the work steps that were indispensable to the invoice verification and posting process plus the related image schemas. In a second step, image schemas that occurred exclusively in the user's mental model were added.

Three sets of requirements were created, each focussing on a coherent set of sub-tasks of the user. This included requirements for (1) opening invoices from the in-box, (2) verifying and posting of invoices and (3) forwarding of invoices. The earlier presented example of the extracted image schema MATCHING resulted (among others) in the following requirements: "Display digitised data and original image of invoice at the same time." and "Support the user in comparing and matching digitised data against the original image of the invoice." These requirements were linked with the image schema MATCHING (in addition, the image schemas SPLITTING, CONTAINER, CONTENT and FULL-EMPTY were extracted from this work step). Note that although this requirement seems rather trivial, the current system does not provide any solution for it. The users spend unnecessary time and energy with the often hard-to-read image of the original invoice to find the data – such as bank details – they have to compare.

Activity 3: Producing Design Solutions

The third phase is highly iterative as it is tightly coupled with the next activity, evaluation. Design solutions start with rough sketches of the task flow in the system and end with the finer levels of detail in the user interface. The redesigned solution consisted of three main screens that were in line with the three sets of requirements above.

We assumed that image schemas can work as a helpful tool to "translate" requirements into concrete design solutions. Before synthesising single design solutions into the overall user interface of the system, we tried to focus on every requirement independently. For this we used the creativity technique of the morphological box. For each image schema several alternative solutions were sketched. As an example Figure 11.1 shows three alternatives that instantiate the earlier introduced MATCHING-requirement.

After this step the best fitting individual solutions for every requirement were selected and put together into the three screens that were designed to improve the user's current system. The MATCHING-requirement was integrated following alternative two in Figure 11.1. When users want to find corresponding data on the original invoice, they simply put the mouse pointer over the data fields concerned. A coloured highlight that is present in the data screen and the matching area on the invoice image is cutting down search time. This function is possible, because the system already reads the data directly from the digitised invoice. Thus the exact location of the data is known to the system.

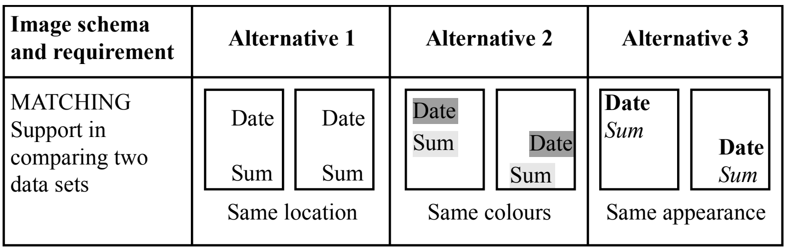

Figure 11.1. Exploring design alternatives for the MATCHING image schema

Image schemas were used for realising all three sets of requirements. It became obvious during this phase how helpful image schemas are as a meta-language for translating requirements into proper design solutions. Image schemas provide abstract descriptions of what to achieve in a user-interface design. In that way they help to guide the design work without being overly restrictive.

Activity 4: Evaluation of Design Solutions

The fourth activity – evaluate the designs against requirements – is already part of the other activities of context-of-use analysis, requirements specification, and design solution sketching. In the evaluation of the existing system (Activity 1) image schemas proved to be really helpful. The evaluation also revealed many inappropriate uses of image schemas in the current system. For example, data was SPLIT across several screens and many selection and confirmation steps had to be done for no apparent reason (RESISTANCE). By simply comparing image schema instances from the system and the user-system interaction with image schemas linked to requirements, strengths and weaknesses of the current system were revealed. Missing or obsolete instances of image schemas were seen as points where further adjustment and improvement were necessary. This method also provided a first indication of how well the re-designed system fits the requirements.

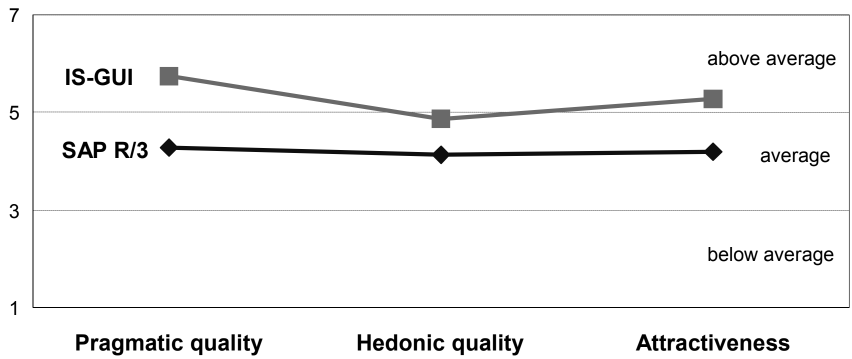

Figure 11.2. Evaluation results obtained with the AttrakDiff questionnaire (comparing the existing system with the redesigned solution)

Nevertheless, feedback from real users is crucial in judging the quality of the produced design solutions. Five users, the three users observed during context-of-use analysis and two of their colleagues, took part in the evaluation. A simplified version of the pluralistic usability walkthrough technique (Bias, 1994) was used. The users were introduced to the image schematic re-designed screens and their functions. Then they were asked to comment on the prototypes and voice their opinion. The users considered the redesigned solution more efficient, because it minimised work steps and reduced confusion. Among others, the introduced matching-function was well approved by the users and seen as a useful feature. After the walkthrough, the AttrakDiff questionnaire was administered (Hassenzahl *et al.*, 2003). It measures the pragmatic quality, the hedonic quality, and the attractiveness of an interactive product. Figure 11.2 shows the comparison between the ratings of the existing SAP R/3 system and the newly designed solution. All three criteria are improved by the image schematic redesign. The differences in pragmatic quality, hedonic quality, and attractiveness are statistically significant at an alpha level of .10 (Fisher-Pitman randomisation test, p=.016, .071, and .056, respectively; N1=4, N2=5).

11.3.2 ISCAT – Documentation of Image Schema Use

To support widespread application of image schemas in a user-interface design process, an online database of image schemas was built. (Please contact the first author to gain access). The database, called ISCAT, has three purposes. Firstly, definitions of image schemas are collected in a single place allowing user-interface designers to consult them if needed. Although the names of image-schemas seem to be self-evident we found that, when extracting them during context-of-use analysis, questions about their specific nature arose (*e.g.* what is the exact difference between a part-whole and a collection image schema?). Providing definitions in the database thus aims at reducing the subjectivity and enhancing the comparability of image schema extraction during context-of-use analysis.

Figure 11.3. Image schema database ISCAT, view of a user interface example

Secondly, designers are provided with examples of image schema applications that they may use for inspiration. For this purpose, a wide variety of user interfaces has been analysed and image schema instances have been extracted (*e.g.* of airplane cockpits, cash- and ticket machines, tangible user interfaces, business software). The database provides brief descriptions of each instance, the effect that it achieves, the strength of the effect, and whether it contributes to or hinders usability (Figure 11.3). Additionally, metaphorical extensions of image schemas as they are analysed in the cognitive linguistics literature are provided. Providing linguistic data aims at stimulating the process of finding design solutions in case no user interface examples are available in the database.

Thirdly, the accumulation of a large number of image schema instances of user interfaces can be used for further research into general rules of image schema application. Thus, implicitly applied design rules can be detected across different user-interface domains and can be subjected to further research. Early analyses of the current set of over 600 image schema instances reveal

- rules of image schema co-occurrences (*e.g.* BLOCKAGE needs to be followed by RESTRAINT REMOVAL, ATTRACTION results in DIVERSION);
- image schema transformation rules (*e.g.* UP-DOWN is readily replaced by FRONT-BACK relations);
- typical problems (*e.g.* UI elements that belong to the same task are often far away from each other without communicating their relation via a link or common container image schema).

11.4 Image Schemas for Inclusive Design

Image schema theory holds a great promise for inclusive design. By keeping to a very basic level of prior knowledge it is assured that schemas will be accessible to the widest possible range of people. Because of their frequent encoding and retrieval from memory they are automatically and subconsciously accessible. The same holds true for metaphorical extensions, *i.e.* basic correlations in experience that have been generalized to abstract concepts. User interfaces that are built on the basis of image schemas and their metaphorical extensions should be more intuitive to use. Preliminary evidence for this stems from experimental research (Hurtienne and Blessing, 2007).

This paper focussed on the practical aspects of including image schemas in a user-centred-design process. It has been shown that they are useful in every step of a user-centred-design process: in analysing the context of use, in specifying requirements, in producing design solutions, and in the evaluation of user interfaces. Image schemas are particularly useful in bridging the gap between requirements and producing design solutions. As the example of the MATCHING image schema showed, designers can easily find solutions that effectively apply psychological principles without the need of a large background in perceptual psychology (in this case the visual pop-out effect supporting parallel visual search; Treisman and Gelade, 1980).

Image schemas provide a meta-language for abstractly describing what meaning user interface elements should transfer to the user. At the same time they do not restrict designers too much in specifying the look and feel of a user interface element (see also Hurtienne *et al.*, 2008).

As the explorative study has also shown, user-interface designs with image schemas can, in principle, enhance the pragmatic and hedonic qualities of a product as well as the product's attractiveness. However, more research has to be undertaken. In particular, carefully designed studies are needed that differentiate between the results of applying a conventional user-centred-design process without image schemas and applying a user-centred-design process augmented with image schemas. In doing this research, the effects of image schemas not only on the usability of the user interface but also on the design process itself (*e.g.* time required to find appropriate design solutions) should be investigated.

Finally, more specific research is needed into the application of image schema theory to the design of more inclusive technology, going beyond software used in a standard business environment. Its promise for designing inclusive user interfaces is high. Applying the theory leads to more intuitive user interfaces that preserve mental capacity for the task at hand, reduce the need for training and are applicable for a wide range of users. First steps have been made that confirm this potential. Inclusive design researchers are invited to go on from here.

11.5 References

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