Image Schemas:
A New Language for User Interface Design?

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Summary

Image schemas are abstract representations of recurring dynamic patterns of bodily interactions that structure the way we understand the world. Cognitive linguistics provides the vocabulary and semantics of a prospective image schema language. We investigate the syntax, semantics and pragmatics of image schemas in hard- and software user interfaces. In a pilot study image schemas were used to re-design an enterprise resource planning application. A final answer to the question posed in the title cannot be given yet, but the results allow a review of the strengths and weaknesses of the image schematic approach to user interface design.

Zusammenfassung

Image Schemata sind abstrakte Repräsentationen wiederholter dynamischer Muster unserer sensumotorischen Erfahrungen. Für die vorgeschlagene Image Schema Sprache stammt das Vokabular und die Semantik aus der Kognitiven Linguistik. Die Syntax, Semantik und Pragmatik von Image Schemata in heutigen Benutzungsschnittstellen wird untersucht. In einer Pilotstudie wurden Image Schemata benutzt, um eine betriebswirtschaftliche Software neu zu gestalten. Obwohl eine abschließende Antwort auf die im Titel gestellte Frage noch nicht gegeben werden kann, erlauben die Ergebnisse eine Bewertung der Stärken und Schwächen des image-schematischen Ansatzes für die Gestaltung von Benutzungsschnittstellen.

As language can be regarded as a method of communication using a system of specialized vocabulary and rules of morphology, syntax, semantics and pragmatics, image schemas can be considered as a language for user interface design. In this paper, we aim to support this claim by first introducing image schemas as the *vocabulary* and their metaphorical extensions as hints about the *semantics* of that language. In addition, we report descriptive studies of image schema instances in user interfaces that investigate the *morphology*, *pragmatics*, *semantics*, and *syntax* of image schemas in a user interface design context. To analyse their usefulness in a user-centred design process, image schemas were applied in an explorative study to re-designing a SAP R/3 application.

Vocabulary & semantics: image schemas & metaphorical extensions

According to Mark Johnson, a pioneer in the domain of image schema theory, image schemas are abstract representations of recurring dynamic patterns of bodily interactions that structure the way we understand the world [3]. Contrary to what their name suggests, image schemas are not reduced to the visual domain – they are 'sensorimotor' and hence inherently multimodal. 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" [3, p.xiv]. The UP-DOWN image schema is the abstract structure of all these experiences. It is neither a full mental image nor an abstract symbol.

About 30 to 40 of such image schemas are distinguished in the literature (see table 1 for the vocabulary of image schemas that was used in the studies below). Not only SPACE image schemas like UP-DOWN are found in this table, but also image schemas of 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.

Table 1: List of Image Schemas.

Group	Image Schemas
BASIC SCHEMAS	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

The semantic transfer of image schemas that stem from physical interactions with the world, to the thinking about abstract, non-physical entities is called *metaphorical extension* of the image schema. For instance, 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 forms 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 sums of 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.”).

Image schemas in human-technology interaction

The universal character of image schemas, their - in the course of life - extremely frequent encoding in and retrieval from memory and their unconscious processing make them interesting for using them as a vocabulary for designing user interfaces that are intuitive to use. A LEFT-RIGHT schema (along with an UP-DOWN schema), for example, may be represented by a joystick on the remote control of a toy car. When the joystick is moved leftwards, the toy car turns LEFT. A rightward move of the joystick lets the toy car turn RIGHT (simple physical mapping). Image schemas can also be metaphorically mapped to represent abstract concepts, e.g. using UP-DOWN in a vertical slider for controlling the intensity of the speaker volume (MORE IS UP) or rate 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 user’s mind, they unconsciously tie the location, movement and appearance of UI elements to their functionality (their semantics).

The authors conducted experiments that validated the claims of image schema theory in the domain of user centred design with a focus on graphical user interfaces [1], [2]. In these experiments an initial set of image schemas involving UP-DOWN, LEFT-RIGHT, SCALE, NEAR-FAR and their metaphorical extensions were used. From these studies, it can be concluded that user interfaces respecting metaphorical extensions of image schemas are not only judged more suitable by users, they also enable users to react faster and with less errors than when the same metaphorical extensions are violated. The application of image schemas in a UI context thus seemed to be valid so that other studies were done to explore their practical usefulness as a design language.

Morphology, syntax, semantics & pragmatics: descriptive studies

We studied a diverse range of user interfaces of airplane cockpits, standard software applications, ticket and cash machines to investigate the morphology, syntax, semantics, and pragmatics of the image schemas found in these UIs. The results of these studies were fed into an online database to make them available to the design and research communities.

Morphology & pragmatics. Because image schemas are abstract descriptions of things in the world, they can be represented differently in a user interface, i.e. they have different morphologies. Representations of image schemas vary according to their pragmatics, i.e. their context of use. For example, the image schema BLOCKAGE generally involves a movement or force that is stopped or redirected by a physical or metaphorical barrier. Specifically, in an airplane cockpit BLOCKAGE can be experienced when using the flap lever. The lever cannot be moved unless a retaining ring is pulled upwards (physical barrier). In a software system BLOCKAGE is presented in a completely different manner. The login procedure denies access after a user has entered an invalid password (metaphorical barrier).

Semantics. Applications of the same image schema also differ in their semantics, as is suggested by the various metaphorical extensions connected to them. But the differences can also be more subtle. The semantics of the BLOCKAGE image schema in the cockpit example above protects the *user* from unwillingly conducting a harmful action. In the Login example, the *system* is protected from harmful action. The effects and meanings of image schemas in the user interfaces of our study are generally found to be in line with the metaphorical extensions found in linguistic analyses. Often the metaphorical extensions are extended by usage conventions. There is, for instance, a strong convention for using the LEFT-RIGHT image schema to express quantity (MORE IS RIGHT, LESS IS LEFT), although a similar metaphorical extension cannot be found in language.

Syntax. Looking at the syntax (the rules) that govern the interrelationships and dependencies between image schemas in user interfaces, one finds, for example, that a BLOCKAGE of the user must be immediately followed by a possibility for RESTRAINT REMOVAL. In the above examples, the upwards pull of the retaining ring or entering a valid combination of user name and password provide instances of RESTRAINT REMOVAL. If a possibility for RESTRAINT REMOVAL is not given after BLOCKAGE, usability will be greatly reduced as can be experienced with each system crash. More of these syntactic rules have been found, and could – after evaluation – form the basis of explicit rules for designing usable interfaces.

Database. The concrete representations of image schemas in user interfaces (the morphological and pragmatic aspects), their effects and meanings to the user (the semantic aspect), and their co-occurrences and interdependencies (the syntactic aspect) were fed into an online database called ISCAT (image schema catalogue). ISCAT also contains definitions and metaphorical extensions of image schemas in language. ISCAT is open to the user interface design and research community for search and also for input of further examples (please contact the first author to obtain access to the database).

Besides sporting interesting morphological, pragmatic, syntactic and semantic aspects, the image schema vocabulary and rules must also stand the test of practice – the application in a user centred design process.

Image schemas in a user centred design process: explorative study

The ISO standard 13407 describes the general activities in a user-centred-design process: (1) specify the context of use, (2) specify the user and organisational requirements, (3) produce design solutions, and (4) evaluate designs against requirements. An explorative study was set up that undertook the redesign of the invoice verification and posting procedure in the accounting department of a beverage company. During the *context of use analysis* three users were interviewed and observed when going about their usual work. Tasks, task sequences, environment, current software support (SAP R/3) and the mental model of the users were analyzed in the traditional way [4]. In addition, image schema analyses were undertaken of task sequences, of user interactions with SAP R/3, of the screens of the SAP R/3 software, and of utterances of the users who were asked to think aloud. Mismatches between the image schematic structure of current SAP R/3 screens and the users' task and mental models were identified and the resolution of these mismatches was specified as image schematic *requirements*. For instance, in thinking aloud users often used FRONT-BACK relations to describe their use of additional information, e.g. lists of contact persons in the company or additional order information. However, the system presented this information either in LEFT-RIGHT fashion on different monitor screens or SPLIT the information into several CONTAINERS that had to be accessed separately. Consequently, putting any supplemental information into one CONTAINER in the BACK was posed as one of the requirements.

We saw that image schemas can be readily identified from task sequences, in users' language and in the user interface of the system. Image schemas allowed capturing requirements in a rather abstract way thus giving designers much flexibility in *producing design solutions*. For example, if main and auxiliary information are to be shown as an instance of the FRONT-BACK image schema the designer is free to creatively develop different forms of FRONT-BACK appearance (figure 1). Concrete design solutions for image schematic requirements were developed in the same way for other issues and the most suitable ones were selected and combined to form the complete redesign of the SAP R/3 invoice verification and posting procedure.

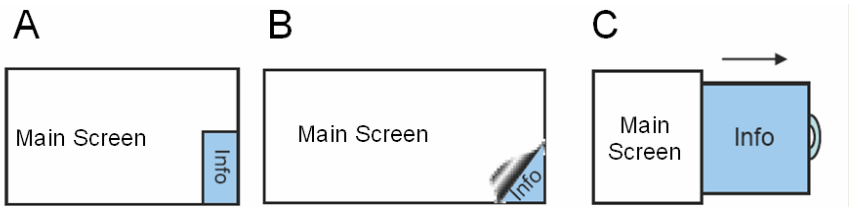

Fig. 1: Design variants of FRONT-BACK arrangements of main (FRONT) and auxiliary information (BACK)

The analysis of the existing system showed that image schemas can also be used to *evaluate* designs. After extracting the image schemas from the user interface elements their effects were evaluated. The effects of image schemas in user interfaces can be described as (1) supporting usability, (2) hindering usability, or (3) being

neutral to usability. Image schemas can also be missing (4). From this evaluation, qualitative suggestions for redesign could be made.

A new language for user interface design?

The question whether image schemas could form the vocabulary of a new language for user interface design, cannot be answered yet. But analysing the strengths and weaknesses of the image-schematic approach might hint at an answer.

One of the major strengths of image schemas as a language for design is that they capture aspects of human experience that are deeply ingrained [3] and are applied automatically when interacting with technology [1], [2]. By using image schemas, the experiential aspects of users' activities in their context of use can be captured and – without break – transferred to the requirements and design stages of a product development process. Thus image schemas reduce the gap between requirements and design without unduly restricting the designer. Image schemas can be applied to various domains and user interfaces, be it hardware, software or a combination of both. Analyzing user interfaces for the ISCAT database led to insights into implicit design rules and helped to render them explicit.

While image schemas are good at capturing the *form* of meaning, they add less value when capturing the specific *content* of requirements. Therefore they will not replace traditional methods of context-of-use or requirements analysis but rather complement them for finding forms of better expressing the meaning of user actions in user interfaces. One of the great strengths of image schemas – their abstractness – can also pose a limitation to their use. Image schema extraction seems to be dependant on context and on the analyst's point of view, so designers still have to involve users for prioritizing their findings and re-evaluating their designs.

Image schema theory is a young field of research. So the set of image schemas is not fixed yet and definitions of some image schemas may differ between authors. The studies reported here are the start of understanding the contribution of image schema theory to user interface design. Whether image schemas will form a new language for user interface design depends on their validity, practicability and relevance. Further research will help consolidating our findings so far.

Literature

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