

Publishable Summary

In an ageing society that increasingly depends on technology, the question becomes how to maintain access and usability of technological products for individual users. Previous research has shown that with increasing age users make more errors and become slower in using interactive products. More recent studies could show, however, that it is not old age per se that causes the performance decline, but rather a decline of cognitive abilities and a lack of prior experience with technology. Unfortunately, current approaches in inclusive design rely on models of conscious information processing that are easily affected by cognitive decline. Furthermore the most common approach to design technology is to focus on the prior tool experience of the target user audience. As this tool knowledge is different between generations, this implies designing specific solutions for each user group. Thus, relying on tool knowledge alone cannot be successful in inclusive design, because inclusive design is about designing user interfaces for the most heterogeneous user groups possible.

The aim of this project was to investigate a methodology that promises to help with designing user interfaces that are robust against cognitive decline and that cater for heterogeneous user groups. This methodology was derived from image schema theory. Image schemas are a form of knowledge representation that encodes very basic and repeated sensorimotor experiences in the world. The experience of vertically extended objects and of gravity, for instance, forms the image schema UP-DOWN. Other examples of image schemas include CONTAINER, BLOCKAGE, NEAR-FAR, and PATH (of a list of about 40 image schemas). They describe basic object properties (BRIGHT-DARK, BIG-SMALL), basic spatial relations (UP-DOWN, NEAR-FAR), or the basic dynamics of forces (BLOCKAGE, COMPULSION). Many image schemas show experiential correlations with other sensorimotor experiences. For example, UP-DOWN correlates with quantity (the height of the water level correlates with the amount of water in a jar) and NEAR-FAR correlates with similarity (similar objects or living things tend to occur together in space). These correlations are also encoded in memory and are re-used in the conceptualisation of abstract concepts, e.g. when talking about *rising inflation* or *close colours*. The association of an image schema and an abstract domain is called a metaphorical extension of the image schema.

Image schemas and their metaphorical extensions have been validated through studies and experiments in the cognitive sciences, and their value has been shown for user interface design. Their exploitability for inclusive design had been stated in theory, but was never investigated empirically. As subconscious and automated patterns of thought image schemas and their metaphorical extensions promise the robustness against cognitive decline and the universality needed when designing for heterogeneous user groups. To investigate the usefulness of image schemas as a tool for inclusive design, the project had three overall objectives: (1) Theoretical: To integrate the theory of image schemas with a model of prior-experience with technology. (2) Empirical: To test the predictions of the resulting theoretical framework for different applications and to verify their fitness for practical purpose. (3) Practical: To develop practical guidance for designers, to evaluate the usefulness of this guidance, and to promote the framework as a unifying approach to inclusive product user interface design

The theoretical part of the project involved the adaptation and development of a model of human information processing that integrates conscious and subconscious components of processing. Subconscious processing of information tends to be much faster and is less susceptible to cognitive decline than conscious processing. A second model of a continuum of knowledge sources was adopted to show the relationship between prior experience with technology and more basic sensorimotor knowledge like image schemas. The models were

made simple enough to be used as a communication aid in interdisciplinary teams. Another outcome of the theoretical work was a better understanding of the notion of prior experience as exposure, knowledge, and subjective feeling on different levels of specificity that can inform the discussion about the concept in the future.

In the empirical part of the project, the first study was about verifying the assumption that user interface design can alter the dependency of common usability measures (effectiveness, efficiency, and satisfaction) on prior experience with technology. It could be shown that it is possible to influence the relationship between several experience variables and usability measures by designing a user interface (in this case of a ticket machine) more inclusively. A side effect of this analysis was a verification of the theoretical assumptions about the different facets of experience (see above).

A second study was designed to test the validity of metaphorical extensions of image schemas. To this end, 12 metaphorical extensions of SPACE image schemas were selected and tested with older and younger participants who differed in their prior experience with technology and their cognitive ability. The results confirm the validity of the metaphors for gesture-based interaction. In general, no differences between older and younger participants were found. The metaphorical gestures that they made were largely independent of their prior experience with technology and their cognitive ability, confirming the hypotheses of robustness and universality of image schematic metaphors.

A third study was designed to compare the usefulness of user interfaces based on image schemas and on familiar tool knowledge. To this end, three prototypes of a heating system controller were created using human-centred design methodology and tested with younger and older participants. The results show that the two image-schema solutions are superior to a solution based on familiar tool knowledge – on all usability measures taken. The pattern of results is the same for the older and younger user groups. However, the correlations of the usability measures with cognitive ability and prior technology experience do not differ between the prototypes as was predicted. Further analysis of the data needs to clarify these issues that are of relevance for judging the robustness and universality of the image-schematic designs.

In the practical part of the project, the methodology used for designing the image-schematic heating controller prototypes was further developed and tested with practitioners. In two workshops, the method was taught to requirements engineers, usability engineers and designers and their feedback was collected. The results show that a three-day workshop was better than a one-day workshop in conveying the method and that working on a real design project during the workshop enhances the usefulness of the knowledge transfer. The strength of the image schema methodology was seen as being an abstract language that quickly leads to novel and creative design solutions. The major drawback is the effort required in analysing image schemas from user interview transcripts.

The conclusion of the work is that image schemas and their metaphorical extensions can be a useful tool for inclusive user interface design. Although there are first empirical indications of their robustness and universality, the issue needs to be investigated further. The results of the project were published in conference papers, journal papers and talks addressing the inclusive design and user interface design communities. From the workshops, spin-off projects were developed that transport the methodology further to application in collaboration with small and medium enterprises. Thus the project served as an important bridge from theoretical assumptions to a viable tool that can help to make living with technology easier for as many people as possible.