

Individual Thinking and Acting: Summary of Discussion

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Introduction

The participants in stream I consisted of a very good mixture of people from different disciplines, several of which had not met before. As a result, the short poster presentations, gave rise to numerous discussions, showing not only overlap in results and ideas, but also a strong discipline-dependent use of terminology. The poster presentations and the initial set of questions resulted in a large number of interesting issues, which were grouped and discussed, resulting in three main questions that formed the basis for the second part of the session.

Questions

The issues that arose from the poster presentations and initial discussions are listed below, the three main questions are highlighted.

Terminology:

- How to get to a common terminology of our units of analysis?
- Can images contain concepts?
- What is a concept?

Components of design activity:

- Can we distinguish between necessary vs. irrelevant operations and moves?
- Should we not define difficulty vs. complexity in relative terms?
- Is re-use a form of fixation?

Cognition

- Is cognitive economy a/the common denominator of our work?
 - Is the subconscious process due to tacit knowledge?
- *How does/can cognitive economy play a role in your findings/explanations*

Strategies

- Top-down vs bottom up?
- Is opportunism more successful or is it only more common?

- What is an opportunistic strategy (can a strategy be opportunistic)?
- Is an opportunistic procedure a knowledge driven procedure?
- Are systematic and opportunistic strategies complementary?
- How can we combine “positive” aspects of a methodic (systematic) approach with “positive” effects of “free design”?
- How do descriptive and prescriptive approaches differ? (experiments vs methodology)
- Contrast/compare real-life processes with theoretical models? (frame of reference)?

→ *What are the implications of the findings of strategy research on improving design?*

- Meta-cognition + design process vs. self-organising process?
- How can we predict “good” designs (results) from the activities/processes adopted during the design process? (prediction)
- What importance have for-links to the designer?
- Is there a correlation between for- and back links to the quality of design?

Research method

- What are the effects of data-collection methods on the findings?

→ *Where are we? What are we heading for?*

The following sections summarise the discussions that resulted from the attempt to answer the three identified questions. The statements as expressed by the participants are used in this summary wherever possible, without explicitly citing and naming the participants.

Question 1: How does/can cognitive economy play a role in your findings/explanations?

Discussion

Cognitive economy played a role in all presented research work, either explicitly or, for those not familiar with the term, implicitly. The feeling was that the concept of cognitive economy is an essential factor in explaining design behaviour. Cognitive economy is one of the reasons why we behave the way we do, and with an increasing age of the population, will become a factor of increasing importance.

But what is cognitive economy? From the discussion it appeared that the definition of cognitive economy is not clear. Is cognitive economy a purely mental process, revealing itself, for example in the difference between experts and novices, the former using experience to reduce trial and error? Or is cognitive economy the more general process of allocating and dealing with limited human resources, revealing itself, for example, also in the use of external representations? It was argued that the central reason for cognitive economy is to reduce mental

load, which is necessary when the mental capacity of human beings turns out to be too limited to solve certain problems. This involves both mental processes. e.g. using experience, as well as external representations such as drawings or gestures. In particular in design, but also in other complex situations, we see that experience as well as the use of external representations has a large effect on the quality of the design. A short discussion arose around the aspect of divergent thinking, which at least at first sight is not necessarily effective, requiring more mental capacity, but is considered important for design. No conclusion was drawn.

Research has shown how, in more detail, experts deal with limited mental capacity. First, they form large chunks of knowledge, which they process as units. Second, they also use the contents: they know what the right chunks are. Third, they use, as all human beings, subconscious, settled rules to reduce the problem to a manageable size, e.g. by decomposition or by putting boundaries around the problem. It was emphasised that the use of subconscious rules, does not imply a lack of purpose. Everything has a purpose, the human mind deals with things using functionality. It was argued that the finding that designers can say little about what they are doing, but can afterwards explain the design, shows that design is a purposeful activity yet starts with few explicit rules and thus must rely on other, subconscious rules. This was not accepted by all participants. The fifth was of dealing with limited mental capacity are the already mentioned external representations. These force one to be explicit, to be more complete. In a sketch, more is visible than what was originally drawn 'into the drawing'. Examples are relationships and connections.

The question then arose as to whether we can use and teach techniques to support cognitive economy, such as techniques to select suitable strategies and suitable external representations, and how this affects tools and methods. Can we not only use and teach something we do consciously, e.g. selecting and applying cognitive economy strategies consciously. Research suggests that we handle cognitive economy both consciously and unconsciously, i.e. that at least part of this could be supported.

This lead to the interesting question as to whether we should teach excellent designers or those that go for satisfactory solutions, i.e. whether we should focus on searching for the best or on efficient approaches. It was clear that the contents of 'excellence' has to be defined first. It seems that experts have many routines depending on the situation at hand. There is a difference when between designing something to meet complexity and something less complex. Much of what experts do is rooting.

The effect of these findings on the development and use of methods and tools. was considered to be unclear. Design methods and tools are developed to support designers, that is, to allow designers to solve design problems despite the limits of mental capacity. However, in particular computer tools may actually reduce the mental capacity available for designing because part of the capacity is used for operating the tool.

Proposals

1. The special features of the domain need to be determined: designers create artefacts, this can also include teaching methods, organisations, etc. In the discussion three keywords emerged for this domain: spatial, functional and goal-directed.
2. More needs to be known about ways of achieving cognitive economy as a way to reduce mental load.
3. Tools should be developed to help release mental capacity, and not increase the need for capacity, or disturb the mental processes. The tools should help with the operation, or come up with other operations that achieve the same release of capacity.
4. Sequencing of strategies should be investigated for practice and for teaching purposes. It was suggested that a different framework is needed than currently available. Many functions are not deliberately “designed in”. In preparing such a framework, it should be realised that some of the assumptions about the world are not correct, such as constancy. Designing changes the world *and* us. Physics knowledge does change us but not the world. Designs change our value systems and our behaviour and therefore the effects of our designs have to be considered. We do not capture the essence of science. We borrow ideas from lots of places, without understanding the situation in which these ideas have been generated. One of the essences of design is that it intends to change things. Interestingly, biological essence is not changing, but memory contents is changing all the time.

The following picture shows an attempt to link the issues dealt with in the discussion. The cause of design behaviour is the limited mental capacity of human beings. Cognitive economy is an answer to this cause because it will help reduce mental load and release capacity. The effects depend on the domain (an expert in one domain is not necessarily an expert in other domains). Cognitive economy is realised by several different, generic, strategies, such as chunking and external representation. In order to support these strategies, tools can be developed, as well as guidelines on sequences of strategies.

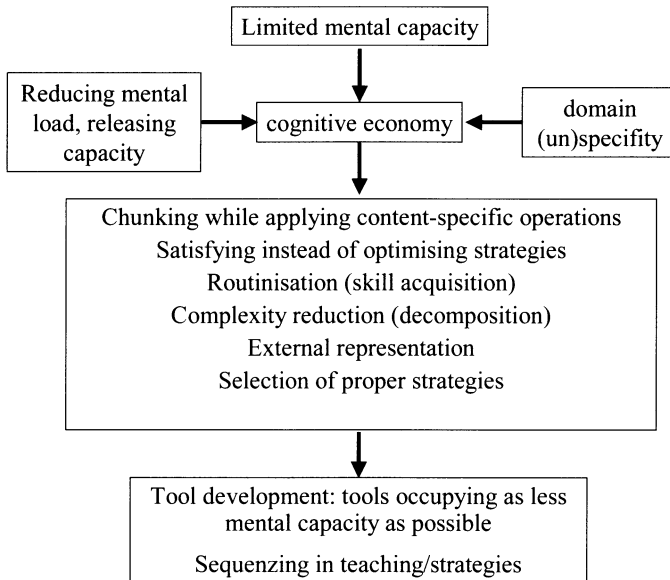


Fig. 1. Mental economy: cause, strategies and support

Question 2: What are the implications of the findings of strategy research on improving design?

Discussion

Several of the presentations referred to opportunism as the main design strategy, that is, as a plausible explanation for the observed behaviour. Designers typically use opportunities at hand to proceed, rather than follow a prescribed path. Humans were considered to be generally opportunistic in their behaviour, because they cannot do anything else but react to their environment. But then, if all of us react to our environment, what is the use of methodologies: we have our view on things and organise our work accordingly.

The findings support the definition of strategy as knowledge-based regulation of action. If we do not have knowledge about the situation at hand, we cannot apply a strategy nor do we have a strategy. This would imply, that design strategies can only be planned shortly before they are to be applied and can only cover a period of time in which the situation does not change so much as to require a different strategy.

It was emphasised that although opportunism is the main strategy, designers are not just muddling through. Some studies indicate that a combination of opportu-

istic and hierarchical strategies is used. There is no one best strategy, but a changing between more hierarchical (often more global) and more opportunistic (often more local) strategies. Both types of strategies are based on cues, the results might be the same, but the cues are different.

It was argued that opportunism is nothing other than organising one's work and methods, but based on what is at hand, rather than on a predetermined plan. This implies the following conditions for opportunism to work: opportunities need to be recognised and ways of dealing with these opportunities need to be known. This distinguishes experts from novices and lay people.

What are the implications of these findings on the teaching of design? Should opportunistic strategies and procedures be taught, and if so, what are these? Can opportunism be taught at all? What are the objectives of teaching design, does one need an abstract concept, such as a process model, behind the cases?

Currently, teaching design involves teaching cases, general guidelines, principles and calculation methods which the students have to combine, or teaching design involves teaching methodologies as normative descriptions of the process of designing as well as the methods that can be used in the various phases. These methods and methodologies are considered to be too restricted. They should be more open to allow adjustment or deviation when opportunitisch arise, yet they should still support (it is always possible to break off a method, but then support is no longer available). The suggestion came up to consider less hierarchical but more networking methods.

Proposals

The two main strategies used in design can be typified using the following terms :

- Opportunistic: bottom-up, situated, context dependent, experience-based, knowledge-driven, task-episode-accumulation (Ullman), local strategy, data-driven
 - Hierarchisch: systematic, methodic, pre-planned, large mental load, structured, 'long'-term, global strategy, plan-driven
1. Both strategies should be used in combination to be able to have an overall direction, yet be flexible to adapt to the situation at hand. For teaching this implies that a methodology is taught to provide an overall framework, but that at the same time the students are pointed at task/situation specific modifications.
 2. Research is necessary to obtain a better understanding of the link between suitable strategies and the characteristics of tasks/situations.
 3. No proposal on how to teach opportunism could be formulated.

Question 3: Where are we? What are we heading for?

Discussion

What is design research? Our research is not to turn researchers into great designers, just as an English department does not produce Shakespeares. They lay the foundation for other people to achieve something near Shakespeare. In the same way, our research can assist us in understanding design and improve our educational system and the production of methods and tools.

Two types of tools need to be distinguished: analysis tools and ‘design’ tools. Currently, the latter are more documentation tools, not synthesis tools. The latter only exists in e.g. VLSI, but this even requires a very detailed specification.

Despite all our research we do not see much being taking up, not in research itself, not in industry and not in teaching.

A clear gap exists between researchers doing descriptive research (improving our understanding of design) and researchers/industries developing methods and tools, although the situation is slightly improving.

It could be argued that where this gap is closed, the gap between research and take up industry would reduce, as methods and tools based on the findings of descriptive studies should better take into account the actual situation and thus realise a better take up. However, even the research results of those that combine the two, are hardly exploited. The gap between research findings and industrial exploitation has been a topic of discussion for many years, but a satisfactory solution has not been found. A participant pointed out that some methods and tools involve so much user involvement that some tools people may not dare to use these, although they are quite happy for consultancies to use these. Other more automatic tools, people have no problem using.

The take up of research results in education has not been discussed, but a reference can be made to the paragraphs about opportunism. Considering the fact that researchers are those that teach, the impact of research results is rather limited.

Proposal

We should work on:

- more rigorous investigations, considering domain (un)specificity
- appropriate models/understanding of design(ing)
- link between experimental findings (human aspect) and development of methods/tools, link between descriptive and prescriptive
- implementation/ use of results in practice and teaching.

Conclusions

The picture of where we are as a community, was considered to be rather fuzzy. Much research is taking place, but an overview is lacking. It seemed that what is

really needed, is an appropriate model of design that can be used to develop strategies, teaching, tools, etc. The aspects of cognitive economy and opportunistic behaviour should be taken into account. The question is whether a concept of flexibility and application of methods can be found, and whether there is a chance of having an appropriate model of design. To do so a framework is needed. The core idea behind the framework should be flexible, balanced design. Some of the existing models, in particular the process-based models may be useful as a starting point.