From novice to expert perceptive behaviour

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1. Introduction

Neisser [Neisser 1976] was one of the first researcher, who tried to integrate activity, perception, and learning. He emphasised that human experience depends on the stored mental schemata, which guide explorative behavior and the perception of an external context. Learning increases constantly the complexity of the mental model (especially the structure of the cognitive knowledge base). This is an irreversible process [Bateson 1972]. One consequence of this irreversibility is, that the contextual complexity must increase appropriately to fit the human's needs for optimal variety and stimulation.

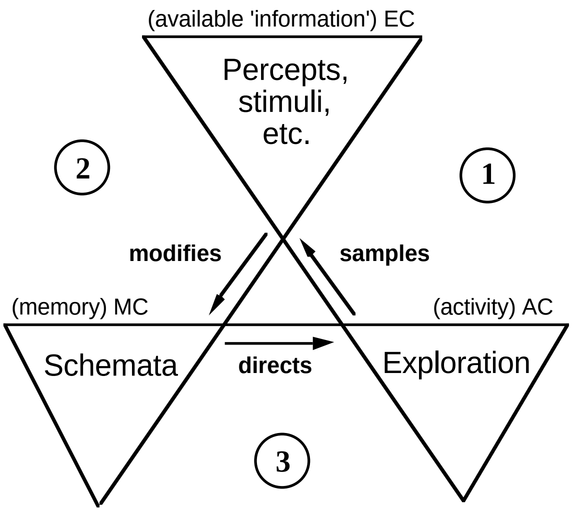

Figure 1. The complete perceptual cycle [Neisser 1976].

If we take this concept into serious considerations, then we can identify several open questions: How is activity coupled with the perception of the external world (the context; see point 1 in Figure 1)? How does perception depend on the internal mental schemata (see point 2 in Figure 1)? What is 'available information'? How do the mental schemata direct actions, and how they are modified by the perceived range of available information (see point 3 in Figure 1)? In this paper we can show how it could be possible to come up with answers to the second question: to analyse the perceived complexity we describe and discuss the outcome of an empirical study.

2. Perception and Complexity

The modern discussion of information and complexity in the context of physics (cf. [Zurek 1991]) is based on the following paradox: Nearly all measures of information increase monotonously with complexity of the stimulus pattern [Grassberger 1986]. But, the subjective impression of each observer is that a medium amount of entropy in contextual patterns contains the maximum of information, and not the pattern with zero or with the maximum of entropy! There must be an inverted U-shaped function between subjective 'information' and the information measured by entropy or complexity. The approaches of the physicists to overcome this paradox seem to be not convincing, because most researchers in this community are constrained by their implicit goal to look for an *observer independent* solution [Crutchfield 1991].

Therefore we have to look for an *observer dependent* measure for the complexity of a perceived context. This problem is difficult, because we have to differentiate between the pre-structured part of perception based on learned mental schemata (available information, see Figure 1) and the unstructured and not predictable part. Only the existence of unknown, but perceivable pattern enable us to integrate new aspects into our stored knowledge (potential available information, see [Rauterberg 1995a]).

An inquiry has been carried out to pinpoint the perceivable and actually perceived complexity of multimedia screens (see [Rauterberg 1995b]). The perceivable complexity is strongly influenced by the number of objects--and their relations to each other--on the screen. But, what is a "visually distinguishable object"?

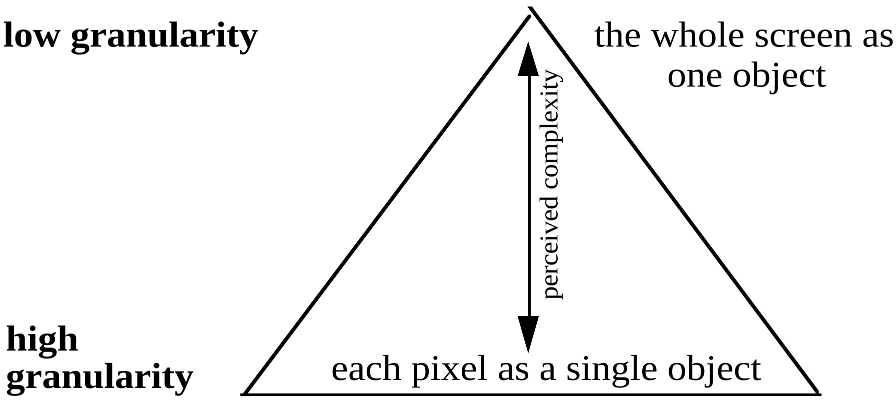

Figure 2. The possible range of perceivable complexity (i.e., the external complexity EC) caused by the level of granularity.

Dependent measure: To find out on which level of granularity visual pattern are classified as single "objects" (see Figure 2), a questionnaire was handed out to a heterogeneous group of potential computer users. To measure the *granularity level* subjects were instructed to answer a 'simple' question: "Estimate the number of different perceived objects on the screendump!" When a subject asked for a more detailed explanation about this question; the standard answer was: "Just have a look, and try to say how many different things do you see".

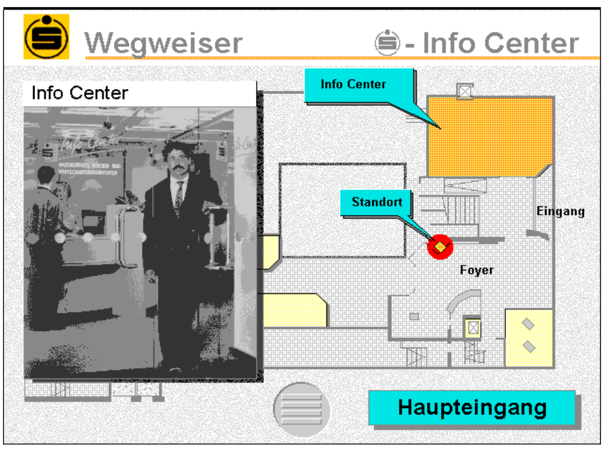

Figure 3. A picture based screendump.

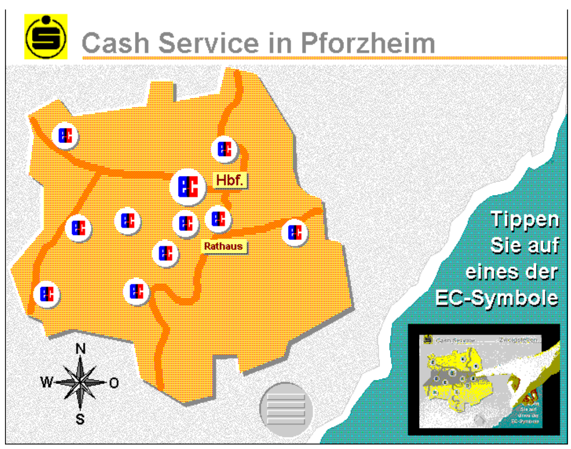

Figure 4. A schema based screendump.

Stimuli: Eight different screen-dumps of a commercial multimedia information system (called "mock-ups") were presented in form of a printed questionnaire. These eight different screen-dumps (the perceivable "stimuli"): text-based masks (see [Rauterberg 1995b]), picture-based masks (e.g. see Figure 3), and schema-based masks (e.g. see Figure 4) were accidentally distributed over 64 different versions of this questionnaire, so, that each questionnaire contained only two different stimuli (sequential order). Each mask was given in a coloured and black & white version (colour effect).

Subjects: A total of 35 women (between 14 and 66 year of life: 36 ±12) and 35 men (between 21 and 55 year of life: 33 ±8) participated (no significant difference in age between both groups). The computer experience of each subject was measured with a selfrating scale ("no experience" = 0 … "expert" = 90). We found a significant difference in computer experience between both groups: 40 ±27 for women, and 63 ±24 for men (T-test, $p \leq .001$); the men had significantly more computer experiences than the women.

Results: The range of the estimated granularity lies between 2 and 35 perceived objects for women and between 3 and 30 objects for men. We could not find a significant difference for the sequential stimulus presentation ("first" = 11.1 ±6.1 objects versus "second" = 10.5 ±6.6 objects; ANOVA, F=0.14, $p \leq .712$). There is also not a significant difference for the colour effect ("black & white" = 10.2 ±5.8 objects versus "colour" = 11.4 ±6.8 objects; ANOVA, F=1.71, $p \leq .194$). Overall, there is no difference between the three mask types ("text" = 10.4 ±5.1 objects, "picture" 10.9 ±7.1 objects, "schema" = 11.1 ±6.9 objects; ANOVA, F=.23, $p \leq .798$). No significant interaction between one of these factors and any other factor was found, except the one described below.

We can find a significant difference between both user groups ("women" = 9.7 ±6.4 objects, "men" = 12.0 ±6.1 objects, ANOVA, F= 6.5, $p \leq .012$). The more experienced men estimated more distinguishable objects than the less experienced women. We can additionally find a significant interaction term between the two factors "sex" and "mask type" (ANOVA, F= 4.2, $p \leq .017$); for men the ranking list of increased number of perceived objects is: picture (10±6), text (12±5), and schema (15±6); for women this ranking list is: schema (8±5), text (9±5), and picture (11±8). The more experienced men tended to estimate a "picture"--in the context of a multimedia interface--rather as one single object than the less experienced women. On the other side, women tended to perceive a schema-based mask with concepts on a very general level.

3. Discussion

From our results we can assume that the complexity of the knowledge structure (MC, see Figure 1) seems to correlate *positively* with the perceived external complexity (EC). This result seems to be in contradiction to the often expressed opinion that a "complex" user interface is not appropriate for beginners. Our result shows a simple way for beginners, how to coupe with an "overwhelming" complexity: a learning system can tune "down" (see Figure 2) to increase its processable visual information capacity with getting more and more experienced in the perceived domain. The longer one is looking on the same thing, the more details will appear!

The next step is to investigate the influence of "hands on" experience--with the presented stimuli (the multimedia information system)--on the granularity level. We assume an increasing shift of the granularity level with increasing knowledge about the system.

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