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ON RESEARCH INTO THE INDIVIDUAL AND COMPUTING SYSTEMS

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Abstract

In order to improve quality of information systems research we must try to select an adequate research approach. When an information system consists of hardware, software and users, we have to consider every component as research objects. Their behaviour is then important. Hardware and software normally behave deterministicly. We can therefore predict their behaviour. But users do not always behave deterministicly. They have their own will and we cannot predict their behaviour. This may recommend different research approaches for computing systems on one hand and for individuals for the other hand. This fact will be demonstrated by taking two studies: a controlled experiment and a survey, and by considering them from different points of view: a) view of human being, b) horizon, c) dynamic system and d) paradigm. In two studies evaluated here the deterministic view were applied, although the voluntaristic view is considered to be more adequate. The causal models (horizon) were applied, although teleological explanations, hermeneutics and phenomenology seem to be more adequate. The human beings were also considered to behave as nilpotent systems, although the theory of dynamic systems supports such a view that they should be considered as self-steering systems. The meaning paradigm should be preferred instead of the behavioristic paradigm applied in those two studies.

Keywords: Research approaches, user/machine systems

Introduction

The basic idea in producing scientific knowledge is an absolute sincerity and a possibility to verify the results of a study. A researcher should publish both data, results and presuppositions of his study. The latter is rarely performed.

A computer scientist really knows what are a computer and its software as research objects. But his knowledge of a basic essence concerning a human being varies a lot (e.g. in user interface studies, Kühme et al. 1992; in user modeling studies, Carberry 1991) or is implicitly taken for granted when a research approach is selected. Computing systems are always made for use of people. It is therefore important that, when the individual and the computing system are both at the same time under study, the researcher is explicitly aware of presuppositions concerning both a human being and a computing system. This paper will shed a new light on this problem by searching and presenting "mental measuring instruments" from the recent literature.

The traditional research methods, e.g. the controlled experiment, survey etc. many times underestimate human beings under study and their capability for self-determination (Heron 1988). A human being must be such one as she is, but researchers try to reduce her to a mechanism or an organism (Varto 1992, cf. Morgan 1986, too).

We shall take two studies, one (Ledgard et al. 1980) is a controlled experiment and the other (Compeau and Higgins 1991) is a survey, for re-evaluation, i.e. we try to analyse the presuppositions concerning both a human being and a computing system in those two studies. To our mind those two studies are representative examples of controlled experiments and surveys, respectively. Although the first study (Ledgard et al. 1980) is old and a progress in computing technology has diminished the value of its results, the problem setting (comparison of two editors, or actually one editor with two presentation forms) is still valid and actual. The study of Ledgard et al. is also compared and contrasted with the known Keystroke-Level Model developed by Card et al. (1980). The latter was chosen, because we can then demonstrate ambitions to use research results for prediction.

In our analysis we shall proceed in such a way that we first present two studies and give some comments on them. We shall then refer to the results of rather recent studies (Iivari 1991, Visala 1991, Aulin 1989 and Lehtovaara 1992). Iivari performed a paradigmatic analysis of seven schools in information systems development. Visala (1991) considerably broadened the empirical framework of information systems research (Ives, Hamilton and Davis 1980). Aulin (1989) developed the covering classification of dynamic systems presented mathematically. In her study Maija Lehtovaara (1992) used Lauri Rauhala's holistic conception of man to construct 10 theses basic to adequate research practices in human science. All the reseachers (Iivari, Visala, Aulin and Lehtovaara with Rauhala) give us many good arguments to criticize presuppositions implicitly taken in those two studies. The strengths and weaknesses of our evaluative study are finally discussed.

Controlled experiment and survey

Controlled experiment

We take the article written by Ledgard et al. (1980) as an example of controlled experiments. The main reason to select this article is that it belongs to the domain of our interest. It is also clearly written. The authors write that their report describes an experiment to test the hypothesis that certain features of natural language provide a useful guide for human engineering of interactive command languages. In particular, they propose the following testable assertion: *An interactive system should based on familiar, descriptive, everyday words and legitimate English phrases*. Their goal was to establish that a syntax employing familiar, descriptive, everyday words and well-formed English phrases contributes to a language that can be easily and effectively used. Users with varying degrees of interactive computing experience used two versions of an interactive text editor: one with an English-based command syntax in the sense described above, the other with more notational syntax. Performance differences strongly favored the English-based editor.

Ledgard et al. (1980) used a slightly modified version of commercially available editor, called notational editor. The second editor, called the English editor, was a remodeled version of the same editor with identical power but with its syntax

altered so that its commands were all based on legitimate English phrases composed of common descriptive words. For example, a command such as:
REPLACE "TOOTH" WITH "TRUTH" is meaningful to the English editor. For the notational editor the same command was expressed as follows:
RS: /TOOTH/./TRUTH/

The design of the experiment was carefully performed. Twenty-four paid volunters served as subjects. They equally represented three groups of users (8 students in each group): "inexperienced users" (university students from an introductory computer science course with less than 10 hours of experience using a computer terminal), "familiar users" (students starting their second computer science course and between 11 and 100 hours of experience) and "experienced users" (students completed several computer science courses and mastered at least two interactive text editors and with more than 100 hours experience). The subjects were informed that the experiment would involve studying text editors and performing some editing tasks. One half of the subjects in each group first received the English-based editor and the other half received the notational editor. All users 20 minutes used both editors for editing. Before the first and after the second editing session, the subjects were asked to state their preference for the notational versus the English editor on a five-point scale.

The dependent measures taken in the experiment were: (1) the percentage of the editing task completed; (2) the percentage of erroneous commands; (3) a calculation of editing efficiency. The independent variables were: (1) type of editor; (2) amount of terminal experience; (3) order of exposure to the editors.

Overall the subjects were only able to complete 48 percent of the editing task using the notational editor as opposed to 63 percent using the English editor. This difference is statistically significant at better than the .001 level. Disregarding all other factors, the error rate for the English editor was 7.8 percent, whereas the rate for the notational editor was 16 percent. The difference is statistically significant at the .01 level. The two editors gave rise to significantly different performance, with the English-based editor being used at 51 percent efficiency, as opposed to 40 percent efficiency for the notational editor. The more experienced users were able to make more efficient use of both editors. No other experimental factors had a significant effect on editing efficiency. All groups clearly preferred the English editor after the editing sessions. Prior to using editors, neither was preferred overall.

The article written by Ledgard et al. received a very positive review in Computing Reviews (CR 21, No 12, p. 547). The only reservation was written as follows: "... although as a COBOL user who has never been able to accept that 'ADD A TO B GIVING C' is better than 'C = A + B', the reviewer hopes that things will not go too far!".

To my mind it is very misleading to use term 'English editor', because the editor does not allow to a use of all kinds of English phrases but very few expressions with seven command-verbs. In the text book of formal languages (e.g. Kurki-Suonio 1971) there is a lot of evidence of that, e.g. a natural language is never decidable. A natural language is also a social product and hence it is changing all the time.

The controlled experiment approach has used to predict the behaviour in the future. The findings of Ledgard et al. recommend the English editor for editing tasks. This fact is based on performance, i.e. on both completion and on efficiency. Card et al. (1980) developed the Keystroke-Level Model (KLM) for user performance time with interactive systems. They assumed that the users are experts performing routine tasks without making any error. The KLM consists as follows:

$$T_{task} = T_{acquire} + T_{execute}$$

where $T_{acquire}$ means acquisition of the task and $T_{execute}$ execution of the task acquired. During aquisition the user builds a mental representation of the task, and during execution the user calls on the system facilities to accomplish the task.

$$T_{execute} = T_K + T_P + T_H + T_D + T_M + T_R$$

The subscripts refer to four different physical-motor operators: K (keystroking), P (pointing), H (homing) and D (drawing), to one mental operator M by a user and to a response operator R by the system.

Pezzarro (1981) stated that a major factor contributing to the value of the KLM paper is that the authors present the results of detailed experimentation showing the model to have a prediction error of 21 percent. Such a figure gives one confidence in using the model as a predictive tool in real-life design work. Reisner (1983) warmly supports that view. By referring to the review of the paper (CR 21, No 10, p. 451) it was, however, stated that a problem that the authors do not mention is that, in applying the model to system design, it may be difficult to produce a comprehensive set of tasks and methods that is representative of typical system use.

Allen and Scerbo (1983) critisize the KLM in many respects (unit tasks and aquisition time, mental time, keystrokes, methods, interpretations of the KLM's predictions). They propose some modifications to the KLM. Shneiderman (1984) did not accept that Card et al. eliminated error data from their raw data. According to him it is difficult to understand the problems people have in learning, using, and retaining memory the interaction commands. If experts never made mistakes, we might accept the KLM's limits, but even in studies reported by Card et al. experts made mistakes in 30 % of the tasks. Shneiderman continues as follows: "Further, the fact that a user's think time and error rates are functions of the system response time is not considered by the KLM; nor are preferences for alternative command names, error induced by complex command syntax, unusual sequencing of subtasks, comprehensibility of screen displays or menu structures, effectiveness of error messages, help facilities, or documentation."

I recognized in Järvinen (1984) that the KLM with time as a performance criterion is suitable for expert users in routine tasks. Already Card et al. told that the KLM is not intended to purposes where errors, learning, functionality, recall, concentration, fatigue and acceptability are criteria. By accepting routine tasks only Card et al excluded problem-solving and application tasks, and by taking experts they excluded novices and casual users.

The results derived both Card et al. on one hand and Ledgard et al. on the other hand seem to be contradictory. If the KLM is applied straightforwardly, i.e. the goal is to minimize the number of keystrokes, it would recommend the notational editor nor the English editor as Ledgard et al. found. The KLM is said to be valid for expert users performing routine tasks without any errors, but Ledgard et al. also accepted users with errors in editing. Is there any other explanation for differing results?

Survey

Compeau and Higgins (1991) considered that understanding individual reactions to computing technology is a central concern of information systems research. Their research seeks to understand these reactions from the perspective of Social Cognitive Theory (Bandura 1986a). Social Cognitive Theory is based on the premise that environmental influences, such as social pressures or unique situational characteristics, cognitive and other personal factors, including personality as well as demographic characteristics, and behaviour are reciprocally determined. Thus, individuals choose the environments in which they exist, in addition to being influenced by those environments. Furthermore, behavior in a given situation is affected by environmental or situational characteristics, which are in turn affected by behavior. Finally, behavior is influenced by cognitive and personal factors and, in turn, affects those same factors. This relationship Bandura refers to as "triadic reciprocality", is shown in Figure below.

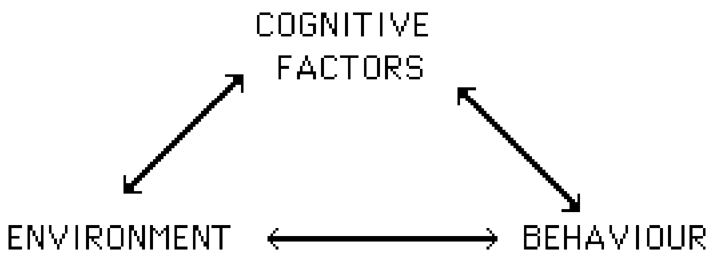


Figure 1. Social Cognitive Theory - Triadic Reciprocality

According to Compeau and Higgins two cognitive factors in particular are given prominence in the theory: (1) outcome expectations, or beliefs about the consequences of behavior and (2) self-efficacy, beliefs about one's ability to successfully execute particular behaviors.

Compeau and Higgins wrote that the premise of triadic reciprocality, which separates Bandura's theory from most other motivational theories, can be fully investigated only through longitudinal research. According to Compeau and Higgins it is, however, possible to examine a sub-model to gain at least preliminary understanding of the relationships at work (see Figure 2 below)

Compeau and Higgins claim that while their research model does not test the reciprocal influences, it provides a reasonable explanation of the forces influencing computer usage. The research model indicates that outcome

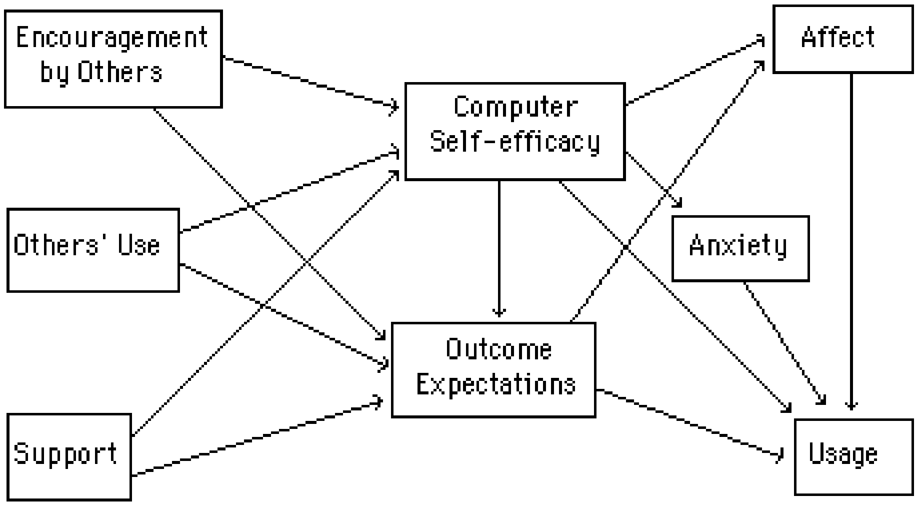


Figure 2. Research model by Compeau and Higgins

expectations and self-efficacy are the two primary cognitive forces guiding computer usage. In other words, individuals' beliefs about the likely consequences of their actions and their judgements of their capability to execute those actions are important determinants of behavior choice. Emotional responses, such as affect and anxiety, are also viewed as influences on behavior, and are also considered to be a function of judgements about self-efficacy and outcome expectations.

The target population for the study was knowledge workers, e.g. managers, insurance adjusters, financial analysts, consultants, accountants etc. The subscriber list of a Canadian business periodical was obtained as a sampling frame to reach this population. After a pretest and a pilot study two thousand subscribers were selected at random from the sampling frame. Of the 2.000 surveys mailed, 1.020 were completed and returned.

One hypothesis per an arrow in the research model was derived. Eleven of the fourteen hypotheses were supported by the analysis. Key findings were that self-efficacy, outcome expectations, affect and anxiety all had a direct influence on computer use. In addition, outcome expectations and self-efficacy were found to indirectly influence computer use through affect and anxiety. The influence of others in the individuals' reference groups was found to exert a small influence on self-efficacy and outcome expectations.

This paper was evaluated in my post-graduate seminar. There were two reasons for selection this paper for reviewing: 1. It was just presented in the ICIS conference, in the greatest annual event on information systems research, 2. It was based on the Bandura's Social Cognitive Theory, and the latter is widely accepted and empirically validated theory of individual behavior which encompasses most of the important concepts in organizational behavior.

The selection was based on an appreciation of the presentation forum and on the abstract. After closer examination of this article I in the seminar presented the following critics (see also anon. 1993):

- the research model by Compeau and Higgins contains only one-directional cause-effect relationships, although the Bandura's Social Cognitive Theory

contains bidirectional relationships (cf. two Figures above); the authors perform a cross-sectional study, although the Bandura's theory requires the longitudinal one;
- there are many violations in using scales, e.g. affect was measured with five items taken from the Computer Attitude Scale; the scale measuring anxiety was also broken; you cannot break the ready-made scale, unless you do not compute a reliability and different validity figures for the new shortened scale; the authors developed their own scales for self-efficacy and outcome expectations without computing reliability nor validities; during the data analysis they found that their outcome expectations scale had two dimensions, and they should divide it into two subscales;
- the authors used a structured questionnaire instead of open questions; in that way they determined the domain and its dimensions, i.e. the respondent could not present their own world view;
- the authors were not very well familiar with Bandura's studies, for in numerous Bandura's (1986b) causal analyses there are many variables not included into the research model by Compeau and Higgins; Bandura and Cervone (1983) showed that self-evaluative and self-efficacy mechanisms mediate the effects of goal systems on performance motivation, and both a goal and feedback of performance should be included - but those are not explicitly presented in the Compeau and Higgins' article; in their other study Bandura and Cervone (1986) among other things measured the subjects' self-evaluation and self-set goals and found that self-evaluation operates as an influential motivator only when attainments fall markedly or moderately short of a comparative standard; self-set goals contribute to motivation at all discrepancy levels except when attainments are markedly discrepant from the standard. The relevant self-influences operating in concert at particular discrepancy levels explain a substantial amount of the variance in motivation - self-evaluation and self-set goals seem to be lacking in the Compeau and Higgins' study; Bandura and Schunk (1981) got the finding that supports self-set goals as follows: "Under proximal subgoals, children progressed rapidly in self-directed learning, achieved substancial mastery of mathematical operations, and developed a sense of personal efficacy and intrinsic interest in arithmetic activities that initially held little attraction for them".

An analysis of presuppositions of an individual and computing systems

Iivari

Iivari (1991) analyses seven schools of information systems development. His analysis is based on four major paradigmatic constituents: ontology, epistemology, methodology and ethics of research. Ontology studies the assumptions made about the phenomena to be investigated. Iivari thinks that for information systems (IS) research the objects to be studied are: information/data, information/data systems, human beings in their different roles of IS development and use, technology, and organizations and society at large.

We are here especially interested in views of human beings and information/data systems. For the former Iivari uses classification of Burrell and Morgan (1979) determinism vs voluntarism, and for latter technical system vs organizational/ social system. The classification of information systems Iivari took from Goldkuhl and Lyytinen (1982) who stated that information systems can be viewed as 'technical systems with social implications' or ' social systems only technically implemented'. Iivari also refers to Iacono and Kling (1988) and their distinction between 'tool' and 'institutional' views. Iivari thinks that a tool perspective reflects a technical/mechanistic view of an information system as an artefact, whereas the institutional view clearly emphasizes the social nature of information systems. Two editor systems and a computer studied in the previous section are considered 'technical systems with social implications' or 'tool'.

According to Burrell and Morgan (1979) a deterministic view of human beings regards man and his activities as being completely determined by situation or environment in which he is located, whereas according to the voluntaristic view a man is completely autonomous and free-willed. The view of human beings in two studies in the previous section was clearly deterministic.

Visala

Visala (1991) notes that when we are considering the subject matter of information systems research, we can think about this totality in different conceptual contexts, such as organizational, linguistic, or technical contexts. In order to free us from former presumptions, Visala uses a new technical term 'horizon' instead of 'context'. By referring to Husserl (1913) he calls *horizons* the contexts in which we see things in a similar mode of being (existing in the same sense of the world). According to Husserl's (1913) phenomenological method, the horizons within information systems can be revealed by questioning our way of seeing the subject matter in appropriate modes of preunderstanding. Visala found the following horizons and related research approaches:

Table 2 (Visala 1991): Horizons and associated research approaches

Horizon	Approach
The instrumentally controllable world of nature and technology	Causal models (C)
Purposeful acts of individuals and interest groups, the political 'game'	Teleological explanations (T)
World of meanings, culture, and form of life	Hermeneutics (H)
Social and economics structures	Dynamic structure models (e.g. cybernetics, Y)
The fuzzy horizon of unclassified observations	Statistics (S)
Axiomatic description languages and their interpretations	Formal Methods (F)
Conceptual structures through which the world is given to us	Phenomenology (P)

We also borrow another table from Visala's paper. It sums up the rationale behind the derivation by brief definitions of the approaches and their limits that lead to other approaches

Table 3 (Visala 1991): Approaches and their limits

Approach	Definition	Limits
C	model non-logical necessary relations	human acts cannot be explained causally
T	practical syllogism	not all acts are due to conscious decisions
H	interpretation of alien meanings with preunderstanding	social structures are not purposeful but purposive
Y	cybernetics	do not capture human intentions
S	quantitative dependencies	do not penetrate pretheoretic observations
F	axiomatizable symbol systems	model idealized structures
P	purification of our concepts	subject to critical discussion

All the authors, Ledgard et al., Card et al., and Compeau and Higgins applied causal models in their studies. It might be suitable for computing systems but not for human beings as the first row in table 3 above clearly shows. Teleological explanations, hermeneutics and phenomenology seem to be more adequate.

Aulin

Aulin (1989) differentiates three primary types of causality: causal relation, causal law and causal recursion, from weakest to strongest one. Causal recursion is the type of causality required at the fundamental level of physical theory, and thus at that of natural science generally. It implies a complete state-description of the dynamical system concerned, given by a total state x, as a function of which any property x of the system at any moment t can be expressed: z(t)=z(x(t)). *Causal recursion* is defined for the total state x if there is a transitive recursion of x(t) to any past state x(τ), i.e. if

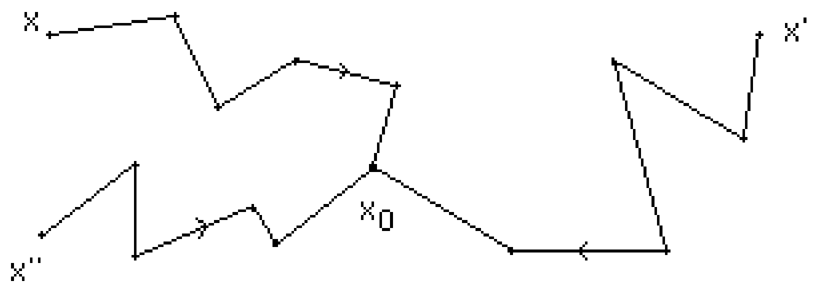
$x(t) = \phi^{t\tau}(x(\tau)),\ \phi^{tt'} \Diamond \phi^{t'\tau} = \phi^{t\tau}$ for $t > t' > \tau$

Thus a system having causal recursion is what Ashby (1972) called "state-determined system".

Causal recursion is *nilpotent*, if there is such a positive integer s and state x_0 that

$\phi^{s}(x) = x_0\ \forall\ x \in X,\ X \subset E,$

$\phi(x_0) = x_0$,
where E is an Euclidean space and X is a set of states of the system.



The intial state x_0 is called the rest state and the nilpotent dynamical system has the property that it comes back to its initial state after the finite number (s) of units of time. We can say that an external disturbance (or stimulus) occurring at the moment t=0 throws the system out of its rest state x_0 to a perturbed state x, after which the nilpotent causal recursion conducts the total state xt=u along the half-trajectory uT^+ until, at the moment t=s, the system is back in the rest state x_0. During its return journey the system gives response to the stimulus. If the same stimulus is offered again, the system gives the same finite total response. Thus it is a memoryless system that does not learn from experience.

If the nilpotent system contains feedback, it is called a cybernetic nilpotent system. If a computer is programmed to solve a finite problem, i.e. a problem that can be solved in a finite number of steps of computation in the machine, it is the cybernetic nilpotent system. (But computers can also be programmed to simulate systems that have a full causal recursion.)

A dynamical system with a full causal recursion does not have any rest state to be reached in a finite number of steps (in a finite time). The causal systems can be classified to two categories: nilpotent systems and systems with a full causal recursion.

```
causal systems
   |
   |--- nilpotent systems
   |
   |--- systems with a full causal recursion
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The mathematical definition of "goal" is based on an infinite process, and thus on a full causal recursion (Aulin 1989). To define exactly the difference between a goal and a task, Aulin assumes that an external disturbance throws the system at the moment t=0 from an unperturbed state x to a perturbed state p. Corresponding to the alternative cases, related to the behavior of the Euclidean distance $\rho(pt, xR^+)$ of the point pt from the half-trajectory xR^+ and to the boundedness or unboundedness of xR^+ we have the following four types of systems with full causal recursion:

1. If, for a small enough δ-neighbourhood $S(x,\delta)$ of x, the Euclidean distance $\rho(pt,xR^+) \to 0$ with $t \to +\infty$ for all $p \in (x,\delta)$, and if the positive half-trajectory xR^+ is unbounded, the system is called *self-steering in state* x.
2. If the convergence of $\rho(pt,xR^+)$ is as above, but the half-trajectory xR^+ is bounded, the system is called *self-regulating in state* x.
3. If, for a small enough δ-neighbourhood $S(x,\delta)$ of x, the Euclidean distance $\rho(pt,xR^+)$ remains finite for all $p \in (x,\delta)$, but does not for all $p \in (x,\delta)$ converge to zero with $t \to +\infty$, the system is called *steerable from outside in state* x.
4. If in any δ-neighbourhood $S(x,\delta)$ of x there is a point p for which $\rho(pt,xR^+) \to \infty$ with $t \to +\infty$, the system is called *disintegrating in state* x.

Here $S(x,\delta)$ is the open sphere with centre x and radius δ. The four definitions obviously exclude one another, and together exhaust the class of all the dynamical systems having a full (i.e. non-nilpotent) causal recursion.

```
causal systems
   |
   |--- nilpotent systems
   |
   |--- systems with a full causal recursion
          |
          |--- self-steering systems
          |
          |--- self-regulating systems
          |
          |--- systems steerable from outside
          |
          |--- disintegrating systems
```

We can ask: Can we find any real system in every category, for example, which real system belongs to the category of self-steering systems? If the uniqueness of the states of mind, along with the goal-oriented nature of thought processes, is typical of human consciousness, the only thinkable causal representation of what takes place in human mind in an alert state is the self-steering process. It is, however, necessary to limit the interpretation so that what is self-steering in human mind is the *total* intellectual process. All the partial processes needn't be self-steering.

Real-world examples of self-regulating systems are: a ball in a cup that has the form of a half-sphere, a room equipped with a good thermostat (self-regulating equilibrium systems); some living organisms like a heart (periodically pulsating self-regulating systems); etc. A flying ball (the resistance of the air is negligible), a frictionless oscillator and a robot are examples of systems steerable from outside. A radioactive atom and a dead organism are disintegrating systems.

Aulin (1989, p. 172) also proved the theorem of dual causality. There are three corollaries of the theorem for characterizing self-steering actors:

Corollary 1. The total behaviour of self-steering actors is unpredictable and indeterministic, also in a probalistic sense.

Corollary 2. Self-steering actors are capable of ultra-self-organization, i.e. of generating not only changes of values of parameters in their causal recursions, but also causal recursions themselves. No other dynamical system has this property.
Corollary 3. Conscious actors, capable of making decisions based on their own will, can be represented by self-steering actors, and only by them.

Aulin (1989, p. 49) shows how for self-steering actors that are able to generate their causal recursion step by step, the causal recursion can be known only ex post, i.e. the unpredictable indeterministic behaviour of self-steering actors can never be programmed beforehand in a computer.

That property is parallel with Mohrman's and Lawler's (1985) conclusions. They studied information technology and change and stated that the technology itself can be changed by those using it. By referring to Schoderbek et al. ((1975) Mohrman and Lawler paid attention to third-order feedback where the technology is adapted to achieve new goals. Feedback provides the inputs for these adaptations of goals and technology, neither of which were predetermined or preprogrammed. Mohrman and Lawler emphasized that there is always a larger system in which a third-order feedback loop leads to redesign and evolution of industrial technologies.

Concerning our cases in the previous section and referring to Aulin above, we can say that computing systems mainly belong to nilpotent systems with causal recursion and predictable behavior. But human beings are nearly self-steering systems with unpredictable behavior. Their causal recursion can be known but only ex post.

Rauhala and M. Lehtovaara

According to Lehtovaara "empirical research must always have a specific object." "Before a researcher can posit and elaborate his hypotheses or decide upon his mode of approach, he must arrive at some preconception of the basic nature of his object. In other words, he must define for himself what his object of inquiry is, come to an ontological decision." Lehtovaara's explicit theoretical basis is Rauhala's philosophical conception of man. "As a rational philosophical elaboration of Edmund Husserl's analysis of consciousness and the existential analyses of Martin Heidegger, Rauhala has evolved a philosophical conception of man which may appropriately be characterized as existential-phenomenological."

Rauhala's (1989) holistic conception of man is based on the view that man is realized in three basic modes of existence: 1. bodily existence (existence as an organic process), 2. consciousness (existence as an experiencing being aware of himself), 3. situationality (existence as relationships to the world within one's individual life setting or situation). These three basic forms have to be presented and discussed as if they were separate but none of them can be reduced to another. Man is always realized as a whole, not only as either organic or conscious or situational.

Rauhala (1978, 163) states that because man's consciousness reflects his situation, his organic existence and action, the totality of his existence manifests in his consciousness as meaning relationships. Therefore, when consciousness is studied, the object being studied is not only consciousness as such but also the wholeness of a human being as it is organized into meaning relationships. This research orientation is called a meaning paradigm (to differentiate it from a behaviour paradigm).

Basing herself on Rauhala's holistic conception of man M. Lehtovaara (1992, 252-255) constructed the following existential-phenomenological research-strategic theses:

Thesis 1. On the basis of present research and knowledge it cannot be defined what and how man will study in the future.
Thesis 2. A study should approach problems in a way adequate to their nature (structure) without losing or sacrificing anything essential.
Thesis 3. A human being is unique as a research object.
Thesis 4. Both statistically generalizable and existence-centered case studies are needed when studying human beings, e.g. children's art of living. Those studies cannot however replace one another but only be complementary to each other. When deciding whether to search for a universal law or to do idiographic research, it is worth while to ask: to what extent is it sensible to try to obtain generalizations and to relate an individual to them before the risk to lose individuality becomes too large.
Thesis 5. Explication of the personal history of the individual is a key factor in seeking to understand him.
Thesis 6. A causal explanation is not regarded as the best possible type of explanation.
Thesis 7. Predictability has not the same status in human science research as it has in natural science research.
Thesis 8. The research system should be so flexible that it makes possible to reveal the essential components of the problems, e.g. disturbances in the art of living.
Thesis 9. The researcher should be fully aware of his own function in the study.
Thesis 10. Instead of having an influence only on a collective level research based on the meaning paradigm should lay the foundation of such remedial actions that are relevant to the individual in question.

Theses 2, 3, 5, 6, 7 and 9 contain critical messages concerning the two studies and their image of man presented in the previous section. Thesis 4 is not a compromise between the behavioristic and the meaning paradigm, it only states the status of the behavioristic paradigm and the meaning paradigm. The former was applied in the cases above.

Discussion

Computing systems in the two studies were considered 'technical systems with social implications' or 'tool' (when Iivari's (1991) arguments were used), the instrumentally controllable world of nature and technology (when Visala's (1991) horizon is used), mainly a nilpotent dynamic system (when Aulin's (1989) classification is applied). M. Lehtovaara mainly studied a human being as a research object. She stated that research methods used in physics are adequate when nature and technology are studied, but not when man is studied as a conscious human being.

Iivari (1991) gave two views of human being, deterministic and voluntaristic. In two studies evaluated here the deterministic view were applied, although the voluntaristic view is considered to be more adequate. According to Visala's (1991) set of horizons causal models were applied in two studies, although teleological explanations, hermeneutics and phenomenology seem to be more adequate. In two studies evaluated the human beings were also considered to behave as nilpotent systems, although Aulin's classification (1989) supports such a view that they should be considered as self-steering systems. M. Lehtovaara (1992) referring to Rauhala would prefer the meaning paradigm instead of the behavioristic paradigm applied in those two studies.

We can conclude that studying computing systems and individuals by means of the same research approach (as were performed in those two studies under consideration and re-evaluation) is not adequate. The human being as an object of study has such essentials that cannot be studied using research methods of physics. What are then suitable research methods? From the articles written by our experts (Iivari, Visala, Aulin and M. Lehtovaara with Rauhala) and referred above can be found advices for selection of a adequate research method. We can also mention Lincoln and Guba (1985) who emphasize a human subject as a researcher and her active role, when a human being is as an object of study.

The approaches used by our experts in consideration of man are not identical, but there are still much similarities e.g. between the voluntaristic view (Iivari), the self-steering system (Aulin) and Rauhala's holistic conception of man. We can also point out that hermeneutics and phenomenology playing a central role in Rauhala's analysis are approaches favoured also by Visala.

References

1. Allen R.B. and M.W. Scerbo (1983), Details of command-language keystrokes, ACM Transactions on Office Information Systems 1, No 2, 159-178.
2. anon. (1993), IS Reviews 1992, University of Tampere, Department of Computer Science, Raportti B-1993-n (forthcoming)
3. Ashby W.R. (1972), Design for a Brain, Chapman & Hall, London.
4. Aulin, A. Foundations of Mathematical Systems Dynamics: The Fundamental Theory of Causal Recursion and its Application to Social Science and Economics. Book Series of Systems Science and Engineering, Pergamon Press, Oxford, 1989.
5. Bandura A. (1986a), Social foundations of thought and action, Prentice Hall, Englewood Cliffs N.J.
6. Bandura A. (1986b), From thought to action: Mechanisms of personal agency, New Zealand Journal of Psychology 15, No 1, 1-17.
7. Bandura A. and D. Cervone (1983), Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems, Journal of Personality and Social Psychology 45, No 5, 1017-1028.
8. Bandura A. and D. Cervone (1986), Differential engagement of self-reactive influences in cognitive motivation, Organizational Behavior and Human Decision Processes 38, 92-113.

9. Bandura A. and Schunk (1981), Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation, Journal of Personality and Social Psychology 41, No 3, 586-598.
10. Burrell G. and G. Morgan (1979), Sociological paradigms and organisational analysis, Heinemann, London.
11. Carberry S. (1991), Second international workshop on user modeling, AI Magazine 11, 57-60.
12. Card S.K., T.M. Moran and A. Newell (1980), The Keystroke-Level Model for user performance time with interactive systems, Comm. ACM 23, No 7, 396-410.
13. Compeau D.R. and C.A. Higgins (1991), A social cognitive theory perspective on individual reactions to computing technology, In DeGross, Benbasat, DeSanctis and Beat (Eds.), Proceedings of the Twelfth International Conference on Information Systems, New York, Dec 16-18, 1991, 187-198.
14. Goldkuhl G. and K. Lyytinen (1982), A language action view of information systems, In Ross and Ginzberg (Eds.) Proc. of the Third Conference on Information Systems, Ann Arbor, Michigan, 13-30.
15. Heron J. (1988), Validity in co-operative inquiry, in Reason (Ed.), Human inquiry in action. Developments in new paradigm research, Sage Publications, London, 40-59.
16. Husserl E. (1913), Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie, Allgemaine Einführung in die reine Phänomenogie, Max Niemeyer Verlag, Tübingen.
17. Iacono S. and R. Kling (1988), Computer systems as institutions: Social dimensions of computing in organizations, in DeGross and Olson (Eds.), The Ninth International Conference on Information Systems, Minneapolis, 101-110.
18. Iivari J. (1991), A paradigmatic analysis of contemporary schools of IS development, Eur. J. Inf. Systs. 1, No 4, 249-272.
19. Ives B., S. Hamilton and G.B. Davis (1980), A framework for research in computer-based management information systems, Management Science 26, No. 9, 910-934.
20. Järvinen P. (1984), On selection methods for studying interactive systems - analysis of the topic as structured by the Keystroke-Level Model, in Sääksjärvi (Ed.), Report of the seventh Scandinavian research seminar on systemeering, Helsinki School of Economics, Studies B-75, Helsinki, 105-118.
21. Kurki-Suonio R. (1971), Computability and formal languages, Studentlitteratur, Lund.
22. Kühme T., H. Dieterich, U. Malinowski and M. Schneider-Hufschmidt (1992), Approaches to adaptivity in user interface technology: Survey and taxonomy, In Preceedings of WG 2.7 working conference on Engineering for human-computer interaction, Aug 10-14, 1992, Ellivuori, Finland.
23. Ledgard H., J.A. Whiteside, A. Singer and W. Seymour (1980), The natural language of interactive systems, Comm. ACM 23, No 10, 556-563.
24. Lehtovaara M (1992), Subjektiivinen maailmankuva kasvatustieteellisen tutkimuksen kohteena (A subjective world-view as an object of educational studies), Acta Universitatis Tamperensis ser A vol 338, Tampereen yliopisto, Tampere (Finnish, English summary).
25. Lincoln Y.S. and E.G. Guba (1985), Naturalistic inquiry, Sage Publications, Beverly Hills.

26. Mohrman A.M. and E.E. Lawler (1985), Information technology and organizational change: A review of theory and research, In McFarlan (Ed.), Information systems research challenge, Harvard Business Press, Boston, 135-164.
27. Morgan G. (1986), Images of organization, Sage Publications, Beverly Hills Ca.
28. Pezarro M.T. (1981), On the Keystroke-Level Model, Comm. ACM 24, No 3, 156-157.
29. Rauhala L. (1978), Psykologia kokemustieteenä inhimillisestä kokemuksesta (Psychology as a science of experience on human experience), Psykologia, Prof. Olavi Viitamäen 60-v. juhlajulkaisu, 149-165 (in Finnish).
30. Rauhala L. (1989), Ihmisen ykseys ja moninaisuus (A monism and pluralism of a man), Sairaanhoitajien koulutussäätiö.
31. Reisner Ph. (1983), Analytic tools for human factors of software, in Blaser and Zoeppritz (Eds.), Enduser systems and their human factors, Lecture Notes in Computer Science 150, Springer-Verlag, Berlin, 94-121.
32. Schoderbek P.P., A.G. Kefalas and C.G. Schoderbek (1975), Management systems, Business Publications, Dallas.
33. Shneiderman B. (1984), The psychology of human-computer interaction by Card, Moran and Newell, Datamation 30, No 1, 236-237.
34. Varto J. (1992), Fenomenologinen tieteen kritiikki (Phenomenological criticism of science), FITTY 30, Filosofia, Tampereen yliopisto (in Finnish).
35. Visala, S. (1991), Broadening the empirical framework of information systems research, in Nissen, Klein and Hirschheim(Eds.), Information systems research: Contemporary approaches and emergent traditions, Elsevier, Amsterdam, 347-364.