A layered model can be very useful as a simplified reference frame to draw applicable results, but it can also serve as a labelling scheme to kid oneself into believing to have solved a problem, while it was not the case.

A2.5 Conclusions

The papers analyzed in Section A2.2 and A2.3 promised a lot, but on closer examination they turned out to be little more than quackery. They are not harmless, however. On the one hand, they cost researchers time and effort; on the other hand - and this is more dangerous - they can mislead people who do not have foundations strong enough in the subject to evaluate on their own how far the contained assumptions are true. To quote Norman (1983):

> "As scientists who are interested in studying people's mental models, we must develop appropriate experimental methods and discard our hopes of finding neat, elegant mental models, but instead learn to understand the messy, sloppy, incomplete and indistinct structures that people actually have."

These papers were selected as particularly bad examples of the nonsense that can take the form of serious scientific work in an area that is by itself still very fuzzy and unclear.

> "The structure of the ISO-OSI model is reminiscent of the Donders-Wundt ladder of processes in inverse, and it would be tempting though inaccurate to match layers in the OSI model with levels in the Donders-Wundt model. The protocol layers discussed in the present paper owe something of their structure to these models, but they cannot be identified with either in any detail". (p.179)

The layered model and the related protocols are proposed as a design and evaluation scheme for human-computer interaction. A practical example is then drawn by Taylor for the Apple Macintosh interface.

> "The Macintosh interface was not designed using layered protocols. Rather, each application has total control of the machine, and consistency of the interface across applications is encouraged by the provision of a large repertoire of routines in the Toolbox. [...] By denying the user access to commands through the keyboard, the Macintosh encouraged (forced) the use of the unfamiliar mouse, and thus popularized this easier method of interaction." (pp. 247-248)

> "[...] Unfortunately, different kinds of objects are moved in different ways. Objects represented by icons can be moved only by dragging, graphical objects in a graphic editor by dragging or by Cut-and-Paste, and text only by Cut-and-Paste. From the layered protocol viewpoint, there seems to be no reasons for this restriction: why should not icons be moved by Cut-and-Paste, or text by dragging?" (p. 248)

This point is quite interesting. Indeed, In version 5.0 of the program Word for Macintosh (released in 1992) the command interface was changed, so that text can now be moved also by dragging.

Taylor concludes - appropriately - with:

> "The layered protocol model has the potential to be used not only in the design of interfaces, but also in their standardization, and in their theoretical and experimental evaluation. Standardization of the lower protocol layers could greatly assist training of users, as well as their ability to transfer from one environment to another. [...] It remains for the test of experience to determine how valuable the model will be in practice." (p. 256)

We can then conclude that there is basically nothing wrong with a layered model for human action, as proposed by Rasmussen (see Section 2.1) or by Taylor here.

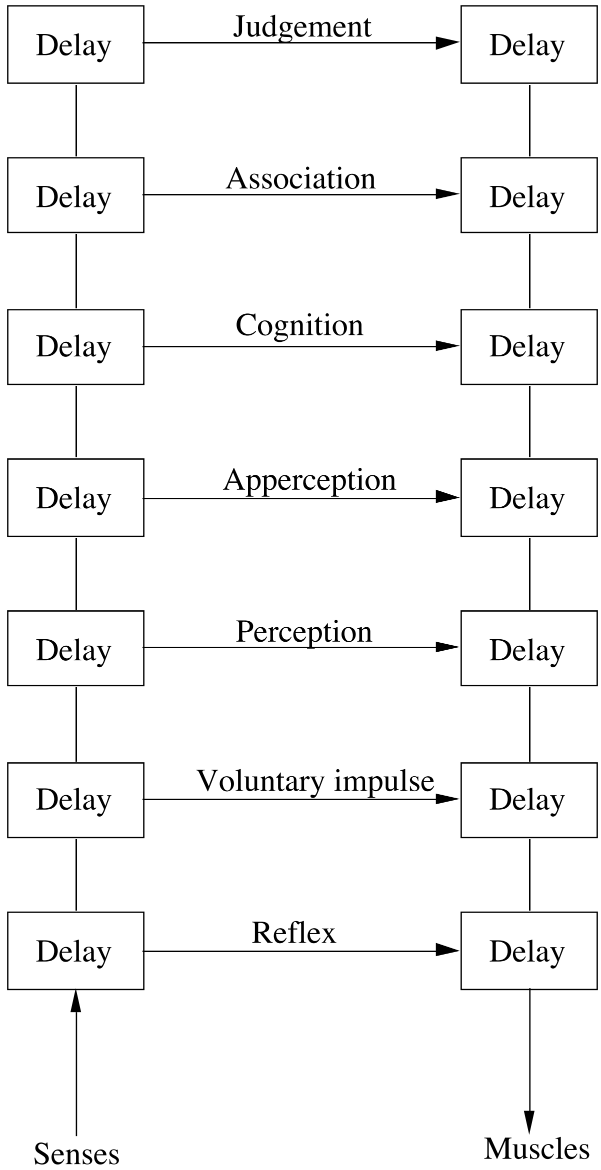

Figure A2.4 Schematic representation of the series of levels of abstraction derived from successive processing stages, as proposed by Wundt in 1880 following Donders in 1862. Processing delays at each stage were supposed to account for differences in reaction times for different tasks. The general rationale is still used to analyse stages of processing in linguistic and other perception (from Taylor, 1988).

> "In this way the criteria that allow two heterogeneous entities to exchange information are achieved: the same set of communication functions and layers will exist in both the human and the computer, the functions are similarly organized, and the human and the computer share a common protocol [47, p.392]." (p.561)

Hale, Hurd and Kasper derive their affirmation (ref. [47] in their article) from *Data and Computer Communications* by W. Stallings [MacMillan, New York, 2nd ed. 1988]. The title of the book does not mention humans, and there is reason to believe that the quote is misleading. If computers can share a common protocol (what was probably told by Stallings) does not automatically imply that also people do so.

The paper ends with the words

> "The proposed human-computer communication architecture provides a structure for integrating the human and computer into a problem-solving system, and is essential for the development of computer systems that provide true collaborative support." (p.563)

The reader will decide the degree of foundation - or exaggeration - of this last statement.

In the whole paper there is only one reference to a practical implementation of this model, as a template for prototype development, but without any data supporting its superiority compared to other models for human-computer communication. The authors have probably entirely misunderstood the point made by the ISO-OSI model and the current capabilities of computers.

A2.4 There is Nothing Wrong with Layered Models

The use of protocols in human-computer interaction is closely examined also by Taylor (1988). His approach is entirely different from the one of the papers examined before. Also Taylor begins with a layered model for mental levels of abstraction, as proposed by Donders in 1866 and Wundt in 1880 (Figure A2.4). Taylor compares these older models with the ISO-OSI frame and warns right from the beginning:

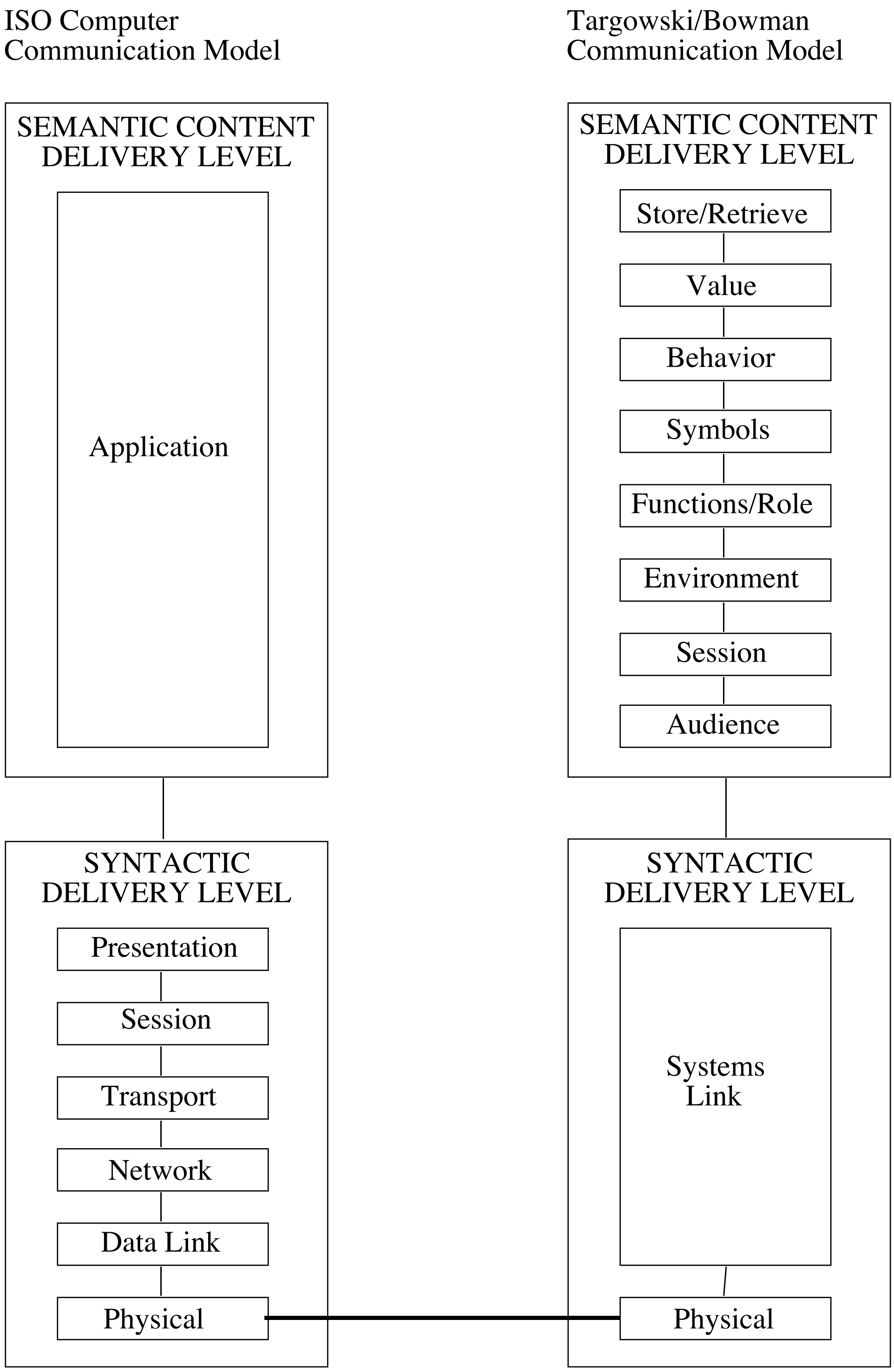

Figure A2.3 Synthesized human-computer communication architecture incorporating syntactic and semantic content delivery subsystems (from Hale, Hurd, and Kasper, 1991) use (and abuse) of his own model; this is an excerpt from the Editorial "The Bandwagon" (Shannon, 1956):

> "While we feel that information theory is indeed a valuable tool in providing fundamental insights into the nature of communication problems and will continue to grow in importance, it is certainly no panacea for the communication engineer or, *a fortiori*, for anyone else. [...] It will be all too easy for our somewhat artificial prosperity to collapse overnight when it is realized that the use of a few exciting words like *information*, *entropy*, *redundancy*, do not solve all our problems. [...]
>
> Workers in other fields should realise that the basic results of the subject are aimed in a very specific direction, *a direction that is not necessarily relevant to such fields as psychology*, economics and other social sciences." [my italics]

The central theme of the paper by Hale, Hurd and Kasper is to build a general model for communication. The authors begin by introducing the OSI model:

> "The benchmark by which all computer communication implementations are evaluated is the International Organisation for Standardisation's (ISO) Basic Reference Model for Open Systems Interconnection (OSI). A corresponding model has been developed by Targowski and Bowman for human communication." (p. 558)

Sorry to say, but OSI is *not* a benchmark for evaluation of computer communication implementations; it is instead a frame for the development of new communication standards (Olsson and Piani, 1992). The Targowski and Bowman's model will not be commented here.

The result of the work by Hale, Hurd and Kasper is showed in Figure A2.3. Their own conclusions are the following

> "Based on the Targowski-Bowman model, the semantic content delivery layers contain the functions necessary to effectively exchange knowledge. Humans implement these layers naturally, and the proposed architecture provides the functionality, guidelines and standards needed to construct compatible computer applications." (p. 561)

How then? Just writing down two pages of labels copied from other publications does not mean that the problem of describing human thought processes and interpersonal communication are solved. Yet these authors continue:

about the capability of machines were at the time very high; among other things it was taken for granted that automatic voice recognition, automatic translation with regard to the semantic contents and music composition in the style of Bach, Mozart and others were only a few years away. Today we know that those expectations were far too high and that our knowledge about the nature of thought and artificial intelligence is much less than what we then believed. To put it mildly, the citation made by Hale, Hurd and Kasper is here entirely out of context (and this is not Mr. Licklider's fault). Yet the statement implies that the computer is an "intelligent entity" able to communicate. Secondly, why should a human being approach a computer the same way he approaches a colleague? Aren't the expectations a bit different? And can a machine really replace a colleague?

The paper by Hale, Hurd and Kasper is eight pages long, plus one full page of references (56 in total). About 1 1/2 pages are used for an introduction to the OSI (*Open Systems Interconnection*) communication model, and 1 1/2 pages for an introduction to the layered mental model by Targowski and Bowman [Targowski, A.S. and J.P. Bowman, "The layer-based, pragmatic model of the communication process", *The J. Bus. Communication*, vol.25, no.1, pp.5-24, Winter 1988]. The main point made in the paper by Hale, Hurd and Kasper is the following:

> "Most current models of Human-Computer Interaction (HCI) implicitly or explicitly assume either the human uses the computer as a tool or as a prosthesis. [...] However, neither the systems perspective, which focuses on data exchange, nor the dialogue partner perspective, which emphasizes the vehicle of interaction, address factors affecting an unabridged exchange of knowledge. [...] Existing HCI models are useful and important in specifying the scope and principles of interaction; however, they do not provide an architecture for effective communication within the domain of collaborative problem-solving systems. This requires an HCI perspective and architecture that explicitly supports the successful exchange of problem-solving knowledge." (p.557)

The problem with the position taken by Hale, Hurd and Kasper is that they imply that a computer has *knowledge*, without expanding on that point. The paper continues with "Foundation for Communication Models" referring to Shannon's model. It is then interesting to compare what Shannon himself thought about the

The paper concludes, quite appropriately, with

> "The analysis developed in this paper is the first step towards a conceptual framework within which to analyze the structure and operation of the next generation of interactive systems." (p.540)

Some final considerations. (1) Gaines makes a very far-going statement in unifying fields such as psychology, sociology, human-computer interaction and computer-computer communication on the base of a "dual identity" for computers; again, he doesn't *prove* anything. (2) This paper - and the approach in general - would not have helped at all in the practical task described in Chapter 5; it probably would not help much in the design of any other human-computer interface either. (3) Choosing the starting assumptions, the limits, the work method and keeping a safe distance to the real world, one may demonstrate anything.

A2.3 The OSI Communication Model, Revised

Hale, David P., Joanne E. Hurd and George M. Kasper: "A Knowledge Exchange Architecture for Collaborative Human-Computer Communication", *IEEE Transactions on Systems, Man, and Cybernetics*, vol.21 no.3 (1991).

The paper by Hale, Hurd and Kasper begins with a reference to an earlier paper by J.C.R. Licklider:

> "Collaboration requires at least two intelligent entities jointly contributing knowledge in a way that moves the whole toward a desired goal state. A similar idea was first presented by Licklider for human-computer partnerships when he proposed a synergistic relationship that would think and process information in a manner superior to either the human or computer alone. Licklider's partnership is based on the notion of a human interacting with a computer in the same way that one interacts with a trusted colleague whose competence supplements one's own." (p.555)

Two considerations. Licklider's work is from 1960 ["Man-computer symbiosis", *IRE Trans. Hum.Factors Electron.*, vol.HFE-1, pp.4-11, 1960]. Expectations have the dual identity shown in Figure 2 [in the original paper, not reproduced here]. They are both technological and humanistic systems and it is human component, the choice available in programming, that determines their roles and behavior in interacting with people." (pp. 539-540)

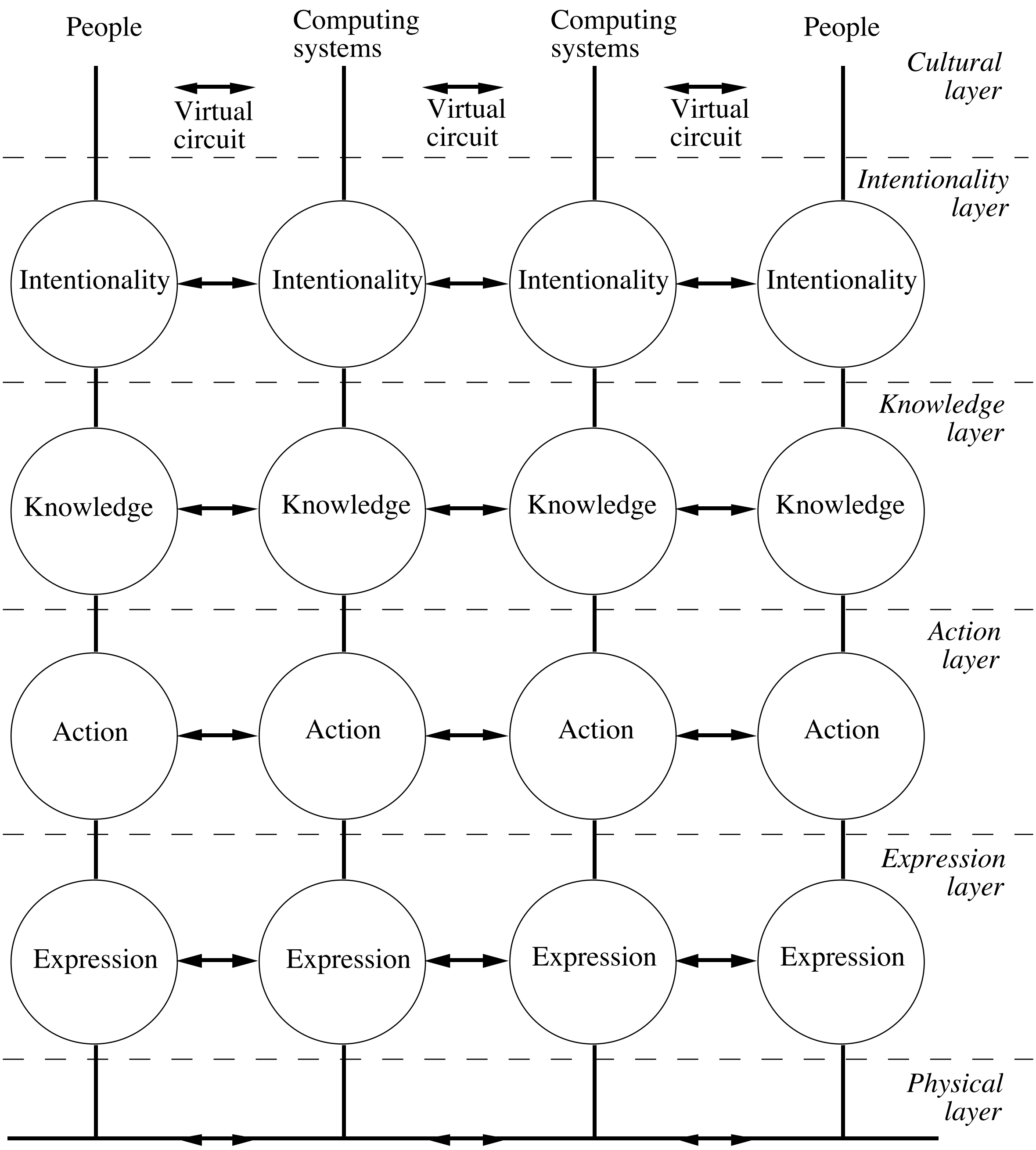

Figure A2.2 Virtual circuits between layers in computing systems (from Gaines, 1988)

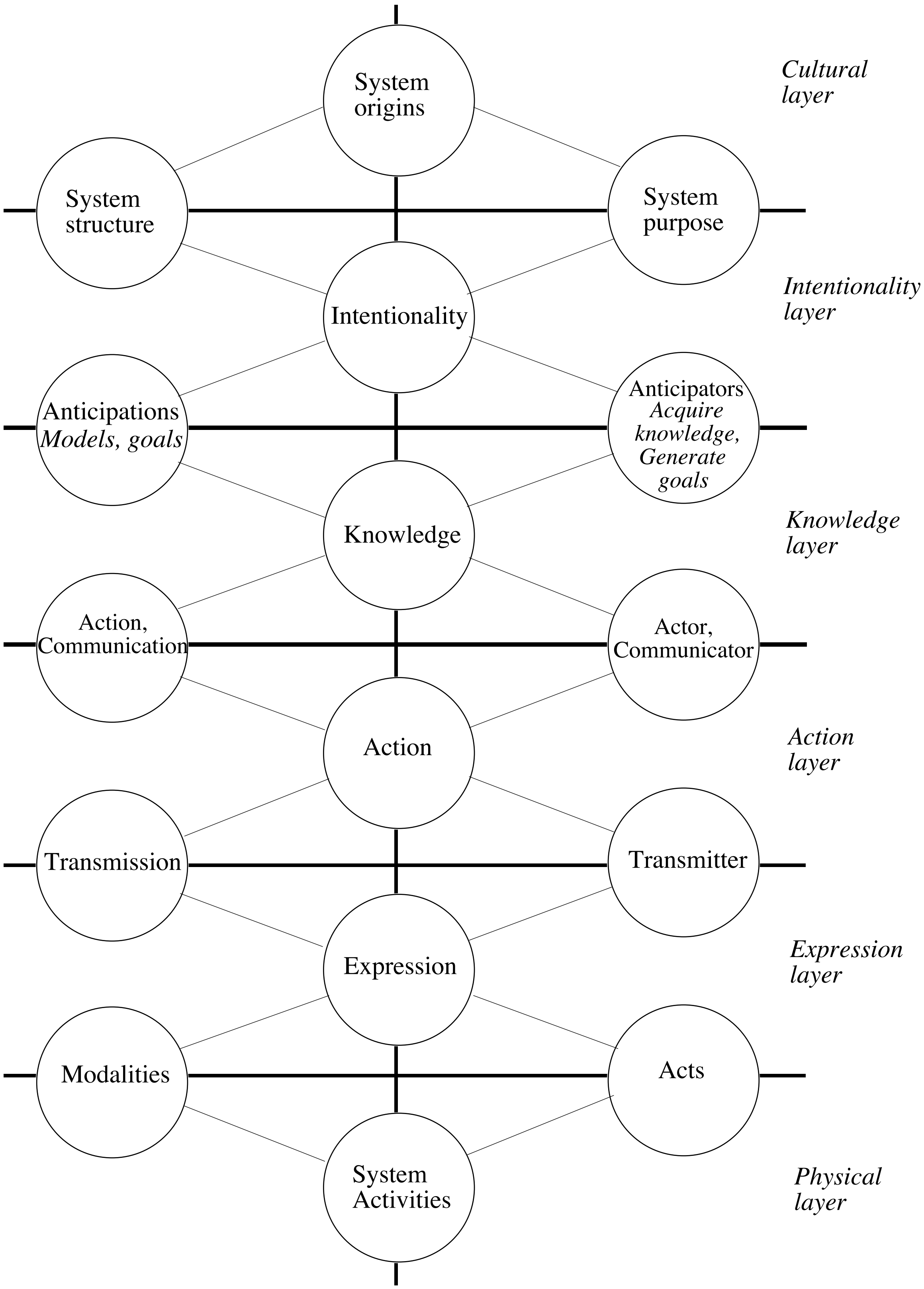

Figure A2.1 The hierarchy of layers in computing systems (from Gaines, 1988) major problems with computers in general and real-time systems in particular is that their behaviour cannot be exactly foreseen beforehand, and that errors may disrupt the operation of a system (see e.g. Littlewood and Strigini, 1992).

Gaines seems to forget that for logical and numerical operations computers are millions of times faster than the human brain, and thus a human can't follow up what the machine is doing, at least not during a normal lifetime. A random-number generator works as an automaton, but it doesn't mean that the outcome is foreseeable. Whenever I have to use an automaton (public pay phone, ticket vendor and the like) I always fear an additional, unspoken "state": that the machine doesn't work and retains the money. Talk about "under the control of people!".

> "The value systems and interpersonal attitudes of the system designer and programmer may have become embedded in the system behavior, making an animistic perspective unavoidable." (p.535)

This point calls for experimental validation. Is it possible to design an experiment in order to find out the national origin or the religion ("the value system") of the programmer of some software? Is there some way to tell whether the word processor I am using now was programmed by a white anglo-saxon protestant, a black, a Chinese, a Catholic, a Muslim or else?

Gaines goes on by proposing a layered model for human-computer interaction (Figure A2.1 and A2.2). Here follow some of his own comments to that model.

> "At the top level [Figure A2.1] the overall computer system originates in terms of purpose and structure as part of the culture within which it is embedded. The cultural layer captures the milieu within which the system has been generated and can itself be subject to detailed analysis." (p.538)

> "Figure A2.2 extends Figure A2.1 to multiple systems showing the virtual circuits in, and between, two people communicating through a computer system. What is particularly interesting about this diagram is that the same distinctions, terminology and model are being applied to the people, their interactions with each other, their interface to the information technology, and its interface to other information technology. The same systems principles apply to the psychology, sociology, human-computer interaction, and computer-computer interaction because computing systems

A2.2 A "New Perspective" on Human-Computer Interaction

A first paper deserving mention as "Pathology" is "A Conceptual Framework for Person-Computer Interaction in Complex Systems" by Brian R. Gaines [*IEEE Transactions on Systems, Man, and Cybernetics*, vol.18 no.4, 1988]. This paper begins with some philosophical considerations:

> "... Habermas' point of view is more akin to a constructivist model of people that sees them as anticipating the future through the development of personal construct systems that are, however, always reconstructable. It is reasonable to suppose that people exhibit both these phenomena, and that any model of personal-computer interaction should be able to encompass those aspects of human behavior that are best modeled as casually based and those that are best modeled as anticipatorily based." (p.532)

This is contradicted by the experimental work of Dörner (1987) and Brehmer (1987), who point out how difficult it is to think and act "anticipatorily" (Section 2.6). It would have been better to qualify how much thinking is reaction to the environment (i.e. a kind of feedback) and how much is handling on an evolutionary model (feedforward).

> "The peculiar property of electronic digital computers is that they are the archetype of deterministic causal systems, modeled in their behavior as finite-state automata whose next state and output are precisely determined by their current state and inputs. However, they are also programmed devices where the transition tables of the automaton are completely under the control of people - what computers do is what we chose them to do. Hence, they are also the archetype of performative, conventional systems, modeled in their behavior as the internal artefacts of people, and whose next state and output are in major part determined by open choices made in programming." (p.534)

In principle, this statement might be true. It is however quite similar as stating that all thinking - and thus psychology - can be reduced to modelling the biochemical activity of the brain. At an atomic level, the workings of the brain do not contradict (as far as we know) quantum mechanics, but quantum mechanics is not a good starting point to describe the thought process. In fact, one of the testing (Gingerich, 1982). By the way, in 1992 the Catholic Church officially admitted that Galileo was right and his method was correct. The Church's stand had an important consequence though: the centre of creative science moved from Italy northward to the Protestant countries, mostly the Netherlands and England.

Today, the situation is different. Many "scientists" sit at comfortable desks in nice buildings in safe western countries, and have no immediate survival needs. Their problem is not how to discover something because it's either wanted or needed, but rather how to justify their salaries and grants. The solution is to produce papers in order to show administrative bureaucrats (the ones deciding about further grants) that research goes on. At this point an optimisation takes place. It is much more economic and less distressing to produce papers on the base of other papers than going out and getting firsthand knowledge from the field. In addition, field knowledge might turn out to be the opposite of what is expected, and it's never good to contradict oneself.

Again, the situation were only half as bad if these people got their satisfaction in receiving the financial grants and keeping their workplace. Unfortunately, they also reach out with publications. The reason for the growing number of nothing-to-say papers might be the most different: the need to build up a curriculum, formal academic requests, or just to feed the writer's ego. The result is a large number of publications that offer little more than noise. And one cannot always tell right away the poor papers from the good ones. It is only after having read them that one discovers how a couple of hours were lost. The cost for the society at large becomes higher, the more people read such articles, the more time is lost.

During the preparation of this work, I had to read a lot of literature about psychology and human factors. I expected the same rigorous approach that is common in other sciences, or even a more rigorous one, to compensate for the intrinsic uncertainties of the field. What I found was - on the side of good articles and reports - much literature dealing with hot air, building on no experimental or practical basis, where complex phenomena are labelled with fancy names, but not explained. Two papers that in my opinion where particularly poor in this respect are analyzed in this Appendix. The name of the section, "Pathology", was used by the Russian physicist Pjotr Kapitsa to denote and disqualify nonsense work.

A2 Pathology

A2.1 Growing Ground for Nonsense

One of the major problems in the field of human-computer interaction is its fuzziness, which makes it difficult to produce exact measurable and verifiable results. People are very different from one another, and this makes the collection and evaluation of data a difficult enterprise; at the end not many results can be generalised. Some physical and cognitive limits that hold in general are known (wavelength perception by the eye, performance of human memory), but when it comes to higher cognitive actions there is still lot of uncertainty. The study of the mental models as described in Chapter 2 is just the beginning of research in a new territory.

This situation could be taken as it is, a fact of nature that offers a wide potential for research and speculation. If mankind manages to survive despite the second principle of Thermodynamics (depletion of energy resources) and the law of gravity (if we fall, it hurts), we should also be able to do fine accepting that we know very little about how our brains work.

Things are not that simple. The way modern research is conducted, mainly financed by the community in form of grants, scholarships, assistantships etc., may lead to distortions in the real purpose and goal of scientific work. People like Newton, Lavoiser, Curie were not working on research contracts. Galileo's work was surely not financed by the Catholic Church, and he was fully aware of the risks he ran by taking a certain stand "*Eppur si muove*!" ("*But the earth* does *move*!"). Now, one of the major reasons why these names are remembered in science textbooks is that they built their theories by going against the mainstream and - most of all - by believing what their observations and their experiments led them to believe, be it the existence of the force of gravity or that of atoms. None of these scientists did research just to satisfy the requirements of an established organization.

In the case of Galileo, what the Church really was afraid of was not Galileo's standpoint in itself, but rather his use of the scientific method of hypothesis