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HOW AND WHERE DO WE LIVE IN VIRTUAL REALITY AND CYBERSPACE - Threats and Potentials

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Contents

ABSTRACT. With Virtual Reality and CyberSpace as latest computer-based developments approaching Mankind at a quickening pace, their dangerous and hallucinating perspectives are linked in this paper to a specific feature of computers: the incomprehensibility of their processes *in principle.* (This will be explained as resulting from the virtual, non-sensible nature of software as well as from the "incompatibility" of process structures on the hardware and operating system levels.) The question is asked whether, or how, an unprecedented threat of globally manipulating the human mind could be successfully faced. Starting with traditional Technology it is pointed out that in spite of damaging influences looming, and as a consequence of Man being exposed to Technology, quite positive inner capabilities have been developed or refined, such as an extended, inward form of the Sense of Touch or novel human qualities of trusting other persons in an organizational role that could be called *superpersonal* in that it does not require to personally know the trusted person. While such was first the experience of technical experts these faculties have already, in the course of time, been acquired by all people, through general or school education. Specifically within Computer Technology a novel form of flexible, lively thinking is required, for coping with both scientific and engineering tasks. Also scientists and practitioners in Computer Technology are, through their professional activity, trained in a kind of *superpersonal sociality* (and this will be used to explain why America is the center of software (and hardware) development).

Again, and this time through Virtual Reality CyberSpace, the stage is set for Mankind to be generally and globally confronted with these issues. The key problem will be to not be drawn into unprecedented and horrifying illusions and addictions but to stand the enormous challenges from Virtual Reality, and to avoid an unparalleled deception. In a stepwise procedure it will be presented how eventually novel human faculties will be individually achieved, much beyond intellectual capacities and out of everybody's own strength and effort. On a larger historical scale, three different steps of modern Science Technology will be identified: Mechanical Technology, Electricity Electrical Engineering, Computer Technology, each of them sided by corresponding modern forms of Art: Painting Sculpture, Music, Eurythmy, respectively. The first phase was started in the 14th 15th century through Leonardo da Vinci, the father of modern Science and Technology as well as of modern Painting, the second phase was established through the second half of the 18th century, the third one came about during the first half of the 20th century. It will be made clear that, and how, Mankind is involved in a global and general education process during the past 500 years, aimed at developing higher or refined senses, or faculties of perception, following a learning procedure of finding and maintaining an inner equilibrium. The present and future perspectives will be addressed.

Figure 1

1 Challenges Through Virtual Reality

Virtual Reality and CyberSpace systems are two recent offsprings of computer Technology. Technically speaking they comprise a quickly growing collection of multimedia application systems. Different from earlier computer applications, however, they have a seductive and at the same time hallucinating effect not only on computer experts, or at least technically skilled people, but they are extremely attractive to everybody. We are experiencing a global phenomenon into which Mankind is drawn at a remarkably fast and quickening pace. In order to understand, possibly comprehend, its potential and dangers we have to first recognize the nature of computers and their processes. While this will be a major focus of the paper we will, to begin with, address some applications that could not even be thought about without the support of Virtual Reality instruments, tools, software systems, thus motivating why there is a serious and well-motivated interest in Virtual Reality, why on the other hand gigantic financial sources are provided for developing and marketing such application systems. As an example from Architecture consider the Frauenkirche, the most renown and beautiful cathedral in old Dresden Germany. It was bombed and completely destroyed in April, 1945, like the whole downtown area. Even the building and construction documents were deleted by the ensuing fire storm. In order to rebuild this church after more than 50 years all available information was collected. Unfortunately this consisted mostly of old paintings (which were not really technically accurate) or photos but this latter material was also incomplete. How e.g. to rebuild the interior from photos of the portals or the towers? The idea was coined to make use of the memories of the (aged) survivors. However, their memory was not technical, they were no architects, not even trained in drawing. Their memories were qualitative. The only way to approach them was to tell them: "Through a data helmet, or head mounted display, and in addition through a data suit which you wear, we will make you experience a possible, a virtual interior of the Frauenkirche. As you walk along you sense this virtual interior in exactly the same way as if you walked through the real church, decades ago. Please let us know how the virtual impression compares to your revived memories of the real experience. If you find a difference we will modify the model accordingly." (A person wearing a head mounted display and a data suit is pictured in fig.1.) Such a procedure of collecting qualitative memories would not be possible with a real rebuilt model. Not only would the costs be prohibitive but modifications might even be technically unrealizable. Since the judgment of the questioned persons was naturally subjective their impressions had still somehow to be objectified, to be tuned. What sounds like Science Fiction has partially done in just this way, in the real Frauenkirche project. It could not have been realized without very powerful computers and the complex software systems for developing the virtual models and their dynamic manipulation.

Of course, it would be better to not destroy a church and then rebuild it but except in war times, such things may happen likewise during an earthquake (like the one in San Francisco, in 1906). Virtual reality is indispensable for a variety of applications in social and cultural areas (such as in our previous example), as well as in scientific or technological projects. There are e.g. new techniques of brain surgery in the works where a tumor in the interior of the brain structure is approached by semi-flexible needle which allows to locally destroy the cancerous tissue without affecting the (non-regenerable) surrounding brain cells. The motion of the needle is supervised on a screen that displays a 3-dimensional picture of the patient's brain from arbitrarily adjustable perspectives, and of the moving needle within. The virtual brain model has been obtained from X-raying the brain in 3 dimensions. More about the technical background can be found in [Göbel96].

Another application of Virtual Reality is a new form of psychological treatment of the Fear of Heights. The patient is positioned on a platform, with his hands on a connected rail. He is wearing a data helmet which makes him experience an elevator on the outside of a high building, with adjustable speed, and he listens to the sound of the wind, and to the traffic noise from the street below. During the fictive ride the platform is in rattling motion. The purpose is to gradually accommodate the patient to in-

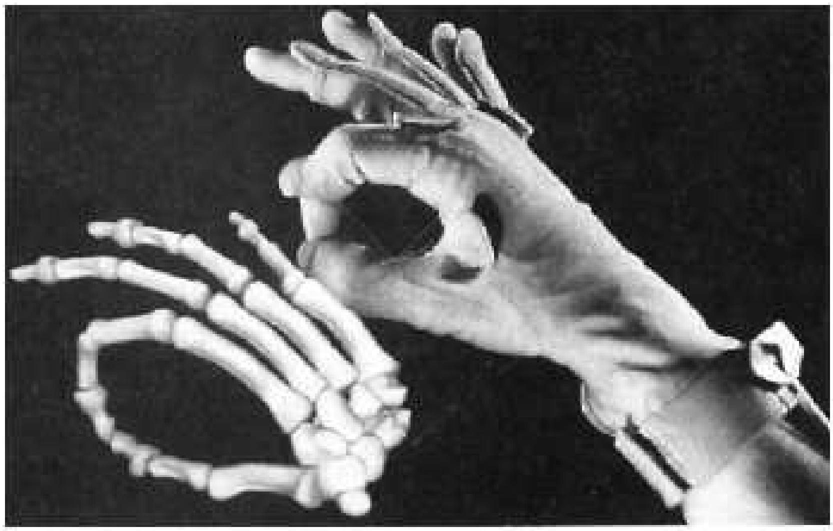

Figure 2

creasing altitudes and with increasing speeds. This could happen through Virtual Reality at very moderate costs, and not at all otherwise (but under financially or individually straining conditions). More technical details are described in [Hodges95].

Automotive engine development, like combustion chamber or piston design can be greatly enhanced by working with, and manipulating, virtual combustion chambers and pistons, and by studying and evaluating the effect of modifications on-line. Using virtual wind tunnels (see fig.2) drastically reduces the costs of shaping bodies for new car models. This is further detailed in [Göbel96].

Female customers who enter a women's wear department in order to purchase a new dress have increasingly difficulties to find expert sales persons (or even sales persons at all, at times), due to both ever larger varieties of fashion and cost reduction policies in the department stores. It would be beneficial for both sides if the customer would first enter a virtual store (which is e.g. based on an extended version of a catalogue-based information system) with visual and audio information. Virtual dresses could even be touched (for testing the fabric) by wearing a data glove (see fig.3), and a virtual sales person if asked, would give information, or ask questions himself. In this way a preselection of the customer profile could be made and presented to a specialized real sales person who then would be able to serve the customer much more efficiently.

On the other side Virtual Reality opens the door for everybody to live

Figure 3

in virtual worlds of yet inconceivable forms of sensual desire and "satisfaction". The US communication and leisure time industry, through the past 7 years, has invested hundreds of billions of dollars into preparing projects like CyberSpace, pursuing long-range economic interests on a gigantic scale. The idea is not only to offer so far unknown forms and settings of sensual pleasure with a real partner by using data gloves, data helmets, data suits and the like. The real big business is anticipated to come from the meeting, experiencing, "living" with virtual partners. For such encounters or intercourse there would be no longer any physical, mental, psychological, or moral barriers to live out any form or degree of desire. Given the "quality" and intensity of the latter experiences, people will then no longer be interested in real partners. This will constitute a loss of reality, even a rejection of reality which, in a comparably very mild version, has been observed with children extensively exposed to TV. However, the CyberSpace seduction is not only badly affecting children but also adults to an at least equal extent!

"Such haunting trends - the information about this is not really hidden, or classified - are incredibly horrible. Soberly speaking, Man is endangered to become a completely patronized being, unable to pursue, or decide about his own destiny. There are even concepts to exploit this trend for streamlining production processes, dictating the taste and choices of individuals, creating a "programmed" leisure time. If at his level, still human features remain procedures of genetic manipulation are conceivable through which these human remainders would disappear. (The official arguments would probably reference public health reasons.) Into the same vein, the idea has been coined to create human clones, human caricatures with a programmable emotional life, through artificial conception. Such human clones could be used for quite inhuman purposes. As a particularly awful vision it is conceivable to create clones which predominantly expose programmable brain functions, thus they could be used as a kind of biological hardware material for revolutionary (neurocomputing) computer architectures. And these are not only concepts! An unnamably horrible future vision!"

2 On the Nature of Computer Processes

Mankind has never faced a global challenge of this kind. And besides the dangerous character of the attack: For the first time there arises the possibility for Mankind to lose its real humanity, its human destination. This is apparent already from the perspectives mentioned. How could this happen during such a short time period of at most 50 years? What is real about Virtual Reality? There must be something real about it since Mankind on the whole could get so broadly involved, even addicted to it. Then, is the manipulation of data, are computer processes real? Are these perceivable as some sort of real objects, not only as thinkable ones? If so, what is their level of reality? Questions like these have not really been dealt with so far, and we will in the sequel approach this crucial issue to some extent.

During the 19th century so-called panorama frames were created in France, to be posted to the inside of circular walls which had a diameter of ca. 70 feet and which were between 20 and 30 feet high. They consisted of painted (later photographed) pictures representing paramount views of landscapes, cities etc. In the interior space there was a kind of stage - circular itself - positioned in such a way that a considerable distance was kept to the posted frames. It was e.g. shaped as a grass-covered hill such that spectators standing on the hill were not able to look down into the space in between. They were prevented by visual blinds from seeing the upper rim of the circular wall. The hill was approached through stairs leading from the ground floor into its center, and the spectators could move freely within a fenced area. Altogether they experienced a perfect illusion of standing e.g. in a nice landscape and recognizing details and perspectives like on a pleasant walk, as if present in concrete, natural space. This made a strong impression on people, and panorama theaters became very popular all over Europe. (Later on, when cinematography was invented something similar yet more intensive happened. People felt a real addiction.) On the other hand, once somebody managed to get beyond the fence on the panorama stage it was immediately apparent to him that there was an artificial stage and, in a distance, just a two-dimensional circular wall. The illusion was unveiled. (In the example of the cinema one could trace the light cone back to the projector.) So there were procedures of getting aware, and even touch, the reality behind the illusion. Are we also able to see, or touch upon, the reality of computer processes, to perceive their real nature?

This is impossible for principal reasons, for the first time in the history of Technology. Due to space limitations we will not be able to go far beyond motivations and intimations.

Where can we trace back virtual images and processes in a computer? At least temporarily they are kept in main memory. More precisely, this is the idea. It seems to be quite concrete, real. However, computer memory is not a storage facility like for potatoes. In the latter, one could grab the potatoes, shuffle them around etc. The management of computer memory is not done through human beings but through operating system software. Software processes are designed through intellectual capacities, they are thought out. On the other hand they are implemented and organized as if they were actions of a human agency, and much worse: Even the software processes which manage data in main memory are stored in this same memory, as if they were data, potatoes etc.! This is a real paradox, and one of the reasons why the software agency called operating system is somewhat incomprehensible. Consequently operating systems are technically unreliable. As an example by comparison let us assume that you wrongly remember to have potatoes in your basement storage. In reality your wife used the space for storing cauliflower. You would need the space for something else, consequently you would remove the stored objects (and thus discover about your wrong memory). But how to remove objects that are thought out? They are all but physical. There is not even an implementational difference between stored data and processes that manipulate them. Imagine you take a bath. The bath tub is a temporary storage for warm or hot water. If you want to remove the used water you simply pull the plug, and the water flows out. In computers one can issue (key in) a command like: "Delete program A in memory". There will be some form of acknowledgment after which you may assume that the program has been removed from the space where it had been stored. But this may actually be wrong. Nothing may have been removed (or overwritten, technically speaking), and this need not even be an operating system fault. However the acknowledgment is clearly illusive. This may be harmful for solving your problem if you want to make use of the current "real" size of free memory space.

Even if you pull the power plug from the electric socket nothing has disappeared from the so-called secondary storage (e.g. hard disk) which is battery-driven and serves both as a mass storage and a backup facility. So when you switch the computer on again the purportedly deleted program may well be loaded into main memory again, unperceivable for the programmer. If you even remove the battery from the machine then after switching the computer on again you cannot use the whole thing as a computer anymore!

Now you could argue: "As paradox and incomprehensible computers may be for the non-expert, regarding their nature and usage, a decent expert should be able - given a reasonable state of practice - to understand the computer and its processes, at least in principle. How could one otherwise design and build computer systems at all?"

Well, how would a computer expert proceed to this end? Systematically, of course. He would structure the problems by introducing a layering scheme as indicated in fig.4 .

A computer consists of hardware components which can be visually perceived and touched. The idea is that in the inside very fast "electronic" processes are running. An endless sequence of operations is executed which is induced, or supported, by electric processes, to begin with. Everything is organized in such a way that nothing happens in parallel, in other words: every single operation is initialized and managed by a central control agency, and there is just one operation executing at any time. (This is the paradigm for uniprocessors but parallel processes in multi-processors e.g. are again centrally managed such that there is only one operation each on any processor at one time.)

Central control is exerted by programs which "reside" in main memory. This is the first paradox: They invoke themselves to execute! These

Layer	Structure
user *(programs)*	sequential structures
operating system *(communication partner)*	processes non-sequentially conceived *(like human organizational processes))*
hardware processes and parts	processes sequentially constructed/ interpreted

Figure 4

programs constitute the operating system. Without going into details it is important to know that each user who works with a computer does not really handle hardware processes but "communicates" with software processes (the operating system) which in turn control the hardware processes. He is only aware of the operating system and of its organizational structures. These, however, are structurally conceived completely different from hardware processes. Operating system activities, like processes in all organizational environments, may conceptually execute concurrently, just as deposit and payment processes performed by the different tellers in a bank lobby take place independently of each other. Technically speaking, operating system processes are designed to be non-sequential. Their cooperation could not even be mentally comprehended otherwise.

What has been said about operating system processes is also true for large computer applications like CyberSpace program systems. These contain operating system calls which are to invoke operating system services for "executing" the application processes. (Throughout this section quotation marks indicate the anthropomorphic wording being commonly used in the context of computer processes.)

As a final paradox a user program which e.g. "invokes", "initializes", "controls", and "terminates" a CyberSpace presentation, is written and structured by the user as a sequence of operations activities as if it would invoke hardware processes (though the latter still occurs with pocket calculators).

This particular 3-layer approach is considered necessary for technical reasons, and the computer experts accept this. Unfortunately the user and operating system process structures are not compatible: You may try to imagine, for comparison, how all activities, transactions etc. in the bank lobby, plus the user service, would have to be organized into a single sequence of operations, just one executing at any time. In practice a gigantic chaos would arise! Even the experts responsible would never be able to find out whether the reorganization was installed correctly. But such is exactly the situation of the computer experts. They are no longer able to really comprehend how the hardware processes would perform as long as they want to understand this from the operating system perspective. Even more incomprehensible, let alone observable, is it to trace how application commands, and user commands into the same vein, are broken down into "electronic" processes. In other words: Even the greatest experts can no longer see (or prove) whether what was inaugurated on a higher layer is correctly performed on the hardware layer. (Frequently it is a question whether it is performed at all.) Thus there is an incomprehensibility of computer processes in principle. For the future it will be of crucial relevance to see how people can responsibly make use, with computers, of something which is not real in terms of sensibility or traceability through the normal five senses, which cannot even be mentally thoroughly grasped by the experts. All concepts (like computer storage or memory) have an irreal, virtual character for them. How would then Computer Technology, let alone Virtual Reality, be comprehended and handled in a responsible way by the remainder, non-expert Mankind?

3 What Do We Learn by Standing Technology?

What to do with such a form of Technology? We have found that it is incomprehensible in principle, yet we recognize that computers, and Virtual Reality through them, have a strong attraction. The more irreal, dream-like a CyberSpace presentation is experienced the more addictive is it to the users. While Computer Technology is largely incomprehensible and uncontrollable for the experts, both in thought and practice, its applications become illusionary for consumers of CyberSpace adventures nearly from the beginning. Since Virtual Reality comes with an attraction of an unparalleled, magic intensity it makes no sense to believe that it would soon go away, or collapse after a chaotic appearance. On the contrary, Virtual Reality is already a global phenomenon, and we will all have to suffer from this technology and its implications. The reality of life will change, a form of reality will emerge in which the unbelievable, the inconceivable will be normal. We will soon have to realize that the coming reality of life - which will very much look like reality crunched by Virtual Reality - will embrace, if not determine, our lives within a relatively short time span (15-20 years). We will not be able to escape from CyberSpace however bad the perspectives may be.

The computer experts have to face a strong challenge from the virtual character of software. While they have to learn designing and managing software systems in a responsible way (a really unsolved problem so far) Mankind as a whole will have to stand, to manage the coming forms of Virtual Reality. Let us assume that we may succeed. What could we have learned from this? Is there anything to learn?

When the first railroad had been built in Germany in 1835 and the train moved along its track between Nuremberg and Fürth (ca. 10 miles distance) at a top speed of about 22 mph (a good horse was faster, of course) quite a few people who watched the event fainted when the steam-spewing locomotive approached. Semi-consciously they sensed the unleashing of the gigantic (mechanical) forces, and this overwhelmed them. Today nobody would faint even if a train would pass very close, at 250 mph. We have lost the archaic form of sensitivity where every thought, every sense impression immediately raised a feeling, and vice versa. However, in a way we have made up for the loss. We have gradually acquired a new form of soberness. This capability allows us to perceive objects, events, life processes separated from feelings, objectively. While outstanding scientists had developed this earlier Mankind as a whole had to go through, even to suffer from, the life changes enforced by the industrialization in Europe and America, during the 19th century. (This process was based on the progress in Mechanical Technology.) In order to simply stand the industrial world Man had to bury, or at least to neglect, much of his feeling life. At the same time he had to get inwardly stronger, and thus learned to face life, the world in an objective, sober attitude. Both in German and in Northern Germanic languages there is the adjective "sachlich" (meaning something like "objective, free of sentiments but just devoted to the subject matter"). It is not an incident that this term was formed in the German language at the dawn of the Industrial Age. (It did not exist in German before Goethe's time.) Due to inner reasons connected with the spirit of the English language there is no such word available there.

An example. Imagine the pilot of a large aircraft, say a Boeing 747. While on cruising altitude turning on the autopilot system he would exert manual control during take-off, landing, and bad weather periods. What is needed for safely flying the aircraft through a bad weather area, or through a landing phase, under low visibility and gusty wind? Since visibility is limited the pilot must be able to anticipate, somewhat sense by instinct, what may occur at a given time so that he would do the right thing in due time. This sounds easy yet we have to note that it takes a good 4 seconds for a 747 to fully react to a corrective action by the pilot. What a distance would the aircraft then cover at landing speed (ca. 180 mph), let alone at cruising speed! How could the pilots acquire the skills needed for handling the aircraft in full responsibility? To put things into perspective: A car driver who would be able, under moderate traffic, to drive his car on a German freeway (autobahn) safely at 100 mph (this is both legal and possible) could not carry the load of a pilot's responsibility because he by far lacks the professional attention and instincts of the latter. In the example the remarkable point is that it is impossible for physical reasons to expect the pilot to build up an extended visual sense. We rather observe that by talent and training a higher capacity of inner attention emerges which has the character of a refined and extended Sense of Touch. (Based on the higher power of attention the pilot has to "grope" beyond his visual range.) Where else but in Technology could one acquire this seemingly limitless expansion of the Sense of Touch? Summarizing the discussion we have complained about the loss of sensitivity during the Industrial Age. With it we have lost an unconscious gift, an inherited talent from the Past, through Technology. On the other hand Technology was, and still is, the basis for building a new refined and extended sensual capability. This educational process is semi-conscious. Besides talent and training, it requires personal initiative, cooperation, determination. The pilot, however, will have to make conscious use of his higher sense capacities, otherwise he would not be able to act responsibly. This is an insight after the fact. However, we should be glad that this positive impact of Technology did not result from scientific reasoning, or from social or artistic efforts. The best representatives of Science at the time of the early technical developments mentioned were very short-sighted, caught in their theories, and philosophers or artists did no longer care much about practical education of Mankind in the Industrial Age. (Also nobody would listen seriously to them anymore.) The scientists had then "proven" that Man would not be able physiologically to stand train speeds beyond 50 mph! It has been beneficial for Mankind that despite suffering from the technological revolution - which has been bad enough anyway - there is good evidence that the inner development, the refinement and extension of sense faculties, was a result of a wise higher guidance, that it was carried by literally wise Higher Powers.

4 Are There More New Faculties to Be Acquired Through Technology?

In the previous section we have seen that standing Technology, and nowadays Virtual Reality in particular, is a serious challenge for Mankind, and we will address later how to approach this problem. Right now, and beyond the example discussion above, we want to further pursue the question in which way the ambivalent gifts provided by Technology still render a basis for stimulating or shaping new and higher faculties. In a broader view it will be a specific objective to not only acknowledge the economic and "cultural" advantages coming with Technology, to not only praise the unprecedented freedom from social or organizational constraints. Instead we will focus on the perspective that solely a conscious use of the higher faculties will enable Man to responsibly confront the challenges from Virtual Reality, in the same way as the pilot is able to responsibly fly the 747 aircraft without being mentally strained under the responsibility for his passengers.

In sizable technological projects experts of different competence are involved. As an example consider a large bridge. Static, metallurgic, traffic experts, architects have to cooperate, among others. Whether a bridge with an unprecedented span between the pylons or the first manned lab in an orbit around a Saturn moon is at stake, it is characteristic that nobody is able to comprehend or know all details of planning, design, test, or construction. At the same time each of the experts involved is faced with a task which reaches considerably beyond all previous professional experience. Also, different from purely scientific projects (like in Physics) extrapolation is not an appropriate principle. Technological solutions do generally not scale up. On the other hand, scientific results do not contribute very much to the construction of a bridge. As an extreme example, Mechanics (as a sub-discipline in Physics) does only give trivial hints how to build an automatic car transmission. However, there is no way to derive construction principles, or calculate structural details such as to ensure that the transmission would safely operate for ca. 100,000 miles (which is the standard today, by-and-large). It is even a corporate rule of production planning that transmissions should not last much longer!

Since already in classical areas of Technology there are no experts for everything *cooperation of experts of different competence is indispensable.* The cooperation is even more needed in large innovative projects since most experts are not absolutely competent, due to lack of experience. Therefore, referring to the examples above, they would not be able to *prove* to the users of the bridge, or to the astronauts, that the functions they realized work properly. This has several implications:

In order to eliminate the uncertainties about the correct functioning (e.g. regarding the durability of a large bridge under realistic conditions) it is impossible to conduct experiments like in Physics because of the lacking scalability. Imagine e.g. Verrazano Bridge connecting Brooklyn and Staten Island in New York State, at the entrance to the harbors of New York City and Newark. It is a suspension bridge with a span of ca. 3/4 miles between the pylons. If one made realistic experiments for testing the durability on the full-scale "model" and the bridge would ensuingly crash the "normal" procedures (in experimental work): to think about what to improve and then build the next "version", make no sense here because of the prohibitive costs (hundreds of million dollars) and the risk of human lives in the (fictitional) experimental phase. So, as a conceptual paradox, the requirement for the bridge project is to realize a solution which is stable, durable, correct *from the beginning.* The bridge must not crash for the next 200 years, a really practical objective!

The engineers involved, with their practically restricted expertise, have to *trust* each other in the sense that each of them works out his share not only to the best of his knowledge but somewhat in full responsibility for the whole project. So they would take responsibility for doing the "right" thing although there is no adequate way to guarantee the correctness. I have been driving across Verrazano Bridge like more than a hundred thousand people every day, and even we as users trusted the experts (who, in turn, need to trust one another).

It is significant here that an expert does not trust another expert because he knows him as a person. Given that one of them needs to be hospitalized for a few weeks the project will not be unduly delayed since the contracting company will put another expert person on who has the same range of expertise. Everybody would trust him just the same as they did with his hospitalized colleague. We will call this a *superpersonal trust*, and we will term the expert responsibility (for the whole project) a *superpersonal responsibility*. These faculties are not dependent on character features of a particular individuality but are related to the expert's inner professional ties to the common project objectives. It is also important to note that though superpersonal, this form of trust is not a passive or blind attitude since every expert plays an active role by taking responsibility for the project as a whole. There is a remarkable phenomenon which further substantiates that superpersonal trust and responsibility are not just abstract or fashionable terms but identify real human attitudes:

Recall that in a large technological project nobody can comprehend the work of an expert of a different area of expertise in full depth. Take also into account that a multitude of divergent interests, personal circumstances (sympathies, antipathies) may easily become sources of conflict between persons, departments, or companies involved, as everywhere in normal life yet more frequently and strongly in the project context of deadline or financial constraints. Then it should be easily possible, and more easily than in normal life, to perform some hidden action which might have hazardous consequences for the project yet would be untraceable because of lacking transparency of the project work. In our previous example the bridge may crash after a few years because an insulted engineer wanted to take revenge. The larger and more complex the project this could be expected to happen. It does not happen this way, however! Consequently, despite personal emotions, or even passion, there evolves a *superpersonal morality* which is formed and trained through work in Technology (different from normal life).

It is from the addressed attitude of superpersonal trust that one expert accepts constraints, even (restrictive) directions on his own work which were issued by an expert of different competence. He would accept them although he would not be able to fully verify their significance or adequacy. In contrast, in personal life, within personal relationships nobody would be willing to be under foreign rule, to be patronized, and least so in his creative fantasy. He would feel his personality hurt, his freedom taken away, and react accordingly.

5 What is New With Computer Technology?

By being immersed into a more and more technical world since about 150 years (and equally practising technological working principles to a gradually growing extent) Mankind has started to develop several new and higher faculties as we have just described for the world of the technological experts. This had to be paid for by giving up on an instinctive sensitivity as was mentioned in section 3. As we now experience how Computer Technology, up to the most recent progress in Virtual Reality/ CyberSpace invades all aspects of life in an unprecedented manner it will be of crucial relevance to learn which new inner human faculties could be developed that would eventually allow Mankind to face the new technological challenge, or, rather to say, onslaught.

When we discussed the "expert" view of the computer (see fig.1 in section 2) we had pointed out that software projects, structures, processes cannot be touched upon, or experienced as real, by sensual perception. They are in this sense illusionary, virtual although the image and the functioning of a computer depend directly on these virtual objects. The term "software" which was created to denote programs, structures, and processes of operating systems, application systems, and user programs congeniously reflects the tool character we have ascribed to them in section 2, in direct correspondence to "hardware". (The spirit of the English language is flexible enough to accomodate the combination of something that is treated and used like a hammer or saw, with the character of a "soft" or virtual reality.) Simply speaking the new problems and challenges of Computer Technology stem from the requirement that software "tools" have to be constructed or used with at least the same accuracy, competence, and responsibility as normal for mechanical or electric devices although they are neither real (as characterized above) nor can software processes be understandably be mapped on the hardware processes which are to act as their "physical" carriers. As for mechanical systems software solutions have to be stable and correct from the beginning since testing process systems which are not fully understood or perceptible at all, does not allow for a full evaluation of their static and dynamic properties.

An example (cf. [Dijkstra68])

In order to realize what the particular problems are for software design, testing, installation an example may help. It is at the same time meant as a kind of test for the reader (hopefully not a disgusting one). In Science and Technology there have been, through history, quite a number of deep fundamental problems. But for most of them people when having been told about them, would have reacted saying: "This is terribly boring. I do not even understand what you are talking about", let alone that they would

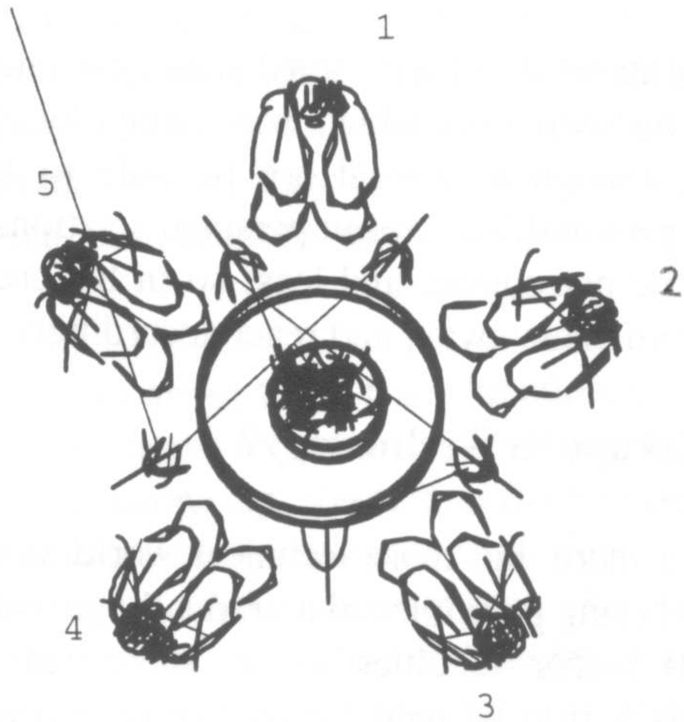

Figure 5

not understand a discussion about how to solve them. In the sequel a fundamental computer problem will be described, a key problem for the design and organization of operating systems. The test will be to ask you whether you

- understood the problem or not;
- found it interesting.

We imagine a big round table. 5 Dutch philosophers are grouped around it as indicated in fig.5. (It is essential that they are Dutch.)

On the table there is a very large pot filled to the rim with freshly cooked long Italian spaghetti. Also on the table there is one fork placed between any two philosophers. (For better clarity the forks in fig.5 have been enlarged and positioned one between any two persons.) As a matter of profession the philosophers think for typically long periods of time but may interrupt themselves at any time. Sometimes they have to take a rest or sleep. They may even claim that they keep thinking while asleep. (Nobody could observe the difference anyway as long as they do not speak.) On the other hand they get hungry at times and would like to eat. So we may accept that the philosophers either think, or they are involved in eating. If they were Italians there would not be any problem since Italians need just one fork for eating spaghetti, and there would be always one fork available for each philosopher, e.g. the one right to him. Since they are Dutch, however, they need two forks for their meal. So *if one philosopher eats none of his neighbors can eat.* In addition to this the philosophers hate each other since they are Dutch. (Dutch Philosophers hate each other, says Prof. E.W. Dijkstra, the author of the problem and one of the "fathers" of Computer Technology. We have to believe him for he is Dutch.) Consequently each philosopher would object against a conflict resolution of the following form: "You will be assigned a fixed number, between 1 and 5. If any conflict arises with a neighbor about who would pick up the fork in between, the philosopher with the smaller number preceeds." All philosophers but number 1 would object on the grounds that then there would be different ranks which they consider unacceptable. So the only way out is that they all are considered of equal importance, and thus *no static priorities must be assigned.*

People eat with different (compared to other people) and varying speed. As philosophers the five Dutchmen would *never accept that a central authority would prescribe how long or how fast they would eat or think.* They consider themselves as *autonomous* persons. Thus they would reject any authority above them, be a central decision impartial or not. What are now the behavioral rules to be given to the philosophers which

- satisfy the mentioned constraints;
- are agreeable to all of them?

Obviously each philosopher has to work under the same rules, otherwise at least one of them would argue to be occasionally underprivileged. A possible and simple candidate algorithm to be passed to everybody could be like this: "Think as long as you like. Once you get hungry grab your right fork. Then you pick up your left fork. Then eat as much as you like, and do not feel pushed by hungry neighbors. After you finished you clean the forks, drop the right fork, then the left one. Then start again thinking."

Now imagine that everybody gets hungry at the same time and proceeds with the same speed. Since a coordination of the different speeds is impossible (the autonomy of the philosophers would be violated) such a history is conceivable. So after everybody picked up his right fork there is no left fork left for anybody. This would result in blocking the philosophers forever. Such a situation is termed *deadlock* for obvious reasons. Clearly *deadlocks must not occur.* (If the philosophers are really autonomous they hopefully would disregard the algorithm once they see the danger.)

In discussing this issue Prof. Dijkstra has elaborated on the weak point of the construction: A philosopher may succeed in picking up one fork without (incidentally) being able to ever receive the other one. Consequently he formulated as a postulate that for every correct solution *it must be ensured that a philosopher succeeds in getting two forks, or he will not receive any.* This is an interesting way out since one can prove that no deadlock can occur as long as the postulate is satisfied.

Let us now assume that somehow a solution has been found which satisfies the mentioned condition. Recall again that Dutch philosophers hate each other. In addition let us assume that in our example philosopher 2 and philosopher 5 hate philosopher 1 much more than they hate each other, that they know about it and thus form a coalition for getting rid of philosopher 1. Let us further considered philosopher 3 and 4 to think whenever needed (such a cooperative attitude would still result from their autonomous decision). If philosopher 1,2,5 get hungry at the same time let philosopher 2 succeed in picking up his right fork. He then picks up his left fork which is free because philosopher 3 is considered thinking. Philosopher 2 starts eating while philosopher 1 cannot pick up his left fork (and consequently also not his right one, according to the postulate). Once philosopher 2 is full he signals this to philosopher 5. This one picks up his left fork (which is still free as we just saw). Then he picks up his right fork which is also free since philosopher 4 is cooperative. Philosopher 2 then returns his forks and starts thinking. Philosopher 1's left fork is now free yet not available to him since his right fork is occupied by philosopher 5. Once philosopher 5 is full he signals this to philosopher 2. This one, in turn, starts eating as did philosopher 5 before etc. Eventually philosopher 1 will starve, and thus philosophers 2 and 5 have reached their goal. (It is easy to see how philosopher 3 and 4 could be cooperative and at the same time themselves eat every now and then. Of course, there should be no way for this to happen, neither on purpose (as in our story) or accidentally.

Education through Computer Technology

Now the problem is completely specified. It is a problem of conflicting access to forks by autonomous philosophers where deadlocks and starvation must not happen even under divergent or conflicting interests. Did you understand it?

As an answer I have always found a broad consensus from the various audiences where I presented it, and there was even a lively and strong interest in the discussion. When E.W. Dijkstra - who was then already a widely recognized computer scientist - presented the Dining Philosophers' Problem more than 30 years ago the reaction of the experts was that this was not really a problem, that Dijkstra had probably lost his head. Even the experts did not understand the relevance of the problem! (This changed within a few years thus honoring both the quality and mental flexibility of the experts.) Since a fundamental problem in operating system design was at stake here, technically speaking, a solution had to be found by all means. Except for special cases, however, this has taken 20 years, despite extensive efforts. Imagine, 20 years of problem solving in a discipline which dates back for no more than 40 years if one neglects the first computing machines based on vacuum tubes. What a complex and deep problem is this! But then, how could it be comprehended today even by novices, mostly by everyone? (Recall that it was normal otherwise for Science and Technology that not only could non-experts not contribute to solving such deep problems, they could not even understand them.) The answer to the question posed is that within the past 30 years Mankind has been pulled semi-consciously or unconsciously into the computer world, to a similar extent to which computers invaded all aspects of individual, social, cultural life. Thus all Mankind is immersed into an educational process, into and through Computer Technology. What are the grapes to be harvested from this education process (even if we cannot all develop the capacity of solving the mentioned problems)?

We are dealing here with problems in software design. These are not mathematical by nature although they can be treated systematically as formal problems. (It is the character of the constraints listed above which is not mathematical.) When I heard about the problem the first time I put my fellow students to the same test that was described above. (We had all received a thorough and wonderful scientific education in Pure Mathematics.) As a result my colleagues found that there was no real problem (like the computer experts had determined a little earlier). So they shrugged their shoulders.

A novel form of flexible, living thinking

If one starts working on a solution for one problem then a paradox emerges soon: The crucial issue is to observe the different interests and activities of all philosophers, under the required autonomy, all at the same time, from all different perspectives. The paradox is that the view or perspective of each single philosopher is limited by his individual interests. In order to be up to the task one has to live through the autonomous processes without any cue from sense perceptions (which is of substantial help in other organizational contexts). Experts are familiar with this. One has to shape the interacting autonomous software processes as a mental effort, as if these appeared with sensible, concrete physical objects, and at the same time they have to be modeled in sharp thought as if they were dynamic properties of geometric objects (although geometric objects have no quality of being autonomous processes).

In this way obviously a new quality of a flexible, living thinking will be acquired through the mentioned training (at least by the experts). This form of thinking must really have a living character, beyond being both pictorial and conceptual as is evident for everybody experienced in such exercises.

Merging Science and Technology

The incomprehensibility of computers, of computer processes in principle, has been discussed in section 2. One of the consequences is that it is impossible to develop correctly functioning large software systems such as operating systems on the conceptual level, by thinking them out. It is impossible to logically derive how to develop, or calibrate software functions, how to embed them into other software processes such that they have a well determined interaction with hardware processes. Even the mentioned new flexible and living form of thinking is not sufficient. Since the problems have to be solved nevertheless the classical engineering principle "learning by doing" is applied. For safely driving a car a technical understanding of all parts and of their functioning is not necessary although a driving school student should get a thorough explanation of how the pedals, steering wheel, the engine and transmission function. However, for becoming a good driver the student has to practice driving, to repeatedly perform all functional activities until he has developed a kind of instinct that reaches into his finger and foot tips. Only thus he may be enabled to handle the car consciously without thinking about it anymore. (The latter would even prevent him from a reasonable driving.)

Scientific thinking and the engineering attitude of learning by doing are to be inseparably combined in Computer Technology, giving this discipline a unique position both within Science and Engineering. While in all other areas, e.g. Electricity and Electrical Engineering, the scientific and engineering perspectives can be treated separately, forming two different worlds (and this happened since Newton, in fact), this does not work in Computer Technology as the example of the Dining Philosophers intimates. While Computer Technology evolved in the two different forms of Computer Science and Computer Engineering this separation has never been meaningful, and consequently these fields of academic and commercial activities have been merged gradually. So what came into the world through *Leonardo da Vinci* as a uniform soul capacity is eventually established again as a novel paradigm, at least in Computer Technology.

With Computer Technology penetrating nearly all areas of professional and private, of commercial, cultural, social, and educational life an observation could be added. Over the past 10 - 15 years, teaching in schools, in particular on the High School level, becomes more and more difficult as long as it relies mostly on lecturing in traditional style, i.e. in appealing to understanding, to thinking capabilities and readiness. From the students there comes an implicit (sometimes even open) request for cooperative learning which includes (at least on their side) learning by doing. This does not only happen in Technology classes but even in English Literature. The young people apparently are ready for the changed life situation. Certainly Computer Technology by itself has an educational impact (although not throughout a positive one). However, this new technology meets the young people who in turn are inwardly prepared for it, who want to get into the computerized world instinctively.

Superpersonal Sociality

A third impact of computers can be identified which reaches even more deeply into soul life than the previous one. You may have asked yourself why America (the United States) is the center of Computer Technology. Attempts of the Japanese (through the past 15 years) to establish an independent, leading position in the world have obviously failed, in particular in the area of software.

Before formulating an answer let me first present an experience. The University of Dortmund/ Germany has a large and excellent School of Computer Science and Engineering. Graduate students take a compulsory class here which is called *project group*. It lasts for a full year and has 16 credits, i.e. a very heavy work load. The themes covered are to be interdisciplinary and, except for an introductory seminar phase, they have the format of guided group work, typically on experimental or practical software development. The group size (= class size) is limited to 12. Since Computer Science students do no differ too much from other young people the group members have not only different interests and skills but also sympathetic and antipathetic feelings for each other (sometimes lasting ones). Frequently, after the students left a group meeting one can easily observe that some cannot even stand other group members. However, during the plenary group sessions, while discussing technical issues and decisions (for the ongoing development) one observes that students closely cooperate even with those whom they personally cannot stand. Instead of helping a despised student and his sub-group selflessly, through concepts, ideas, structural suggestions, one could expect as a "normal" reaction that an attempt would be made to put this student (or his sub-group) at a disadvantage, or even harm him, e.g. by just not giving needed information or a key idea for finding or implementing a solution. As a result the harmed student may not get the needed certificate, a very serious set-back. Obviously it would be impossible to prove the malicious intent.

This example demonstrates how the students, in the pursuit of software development in-the-large, disregard personal sympathies or antipathies. They even put themselves to work as if there was a good social relationship. The reported experience is not incidental. This remarkable and unique attitude is regularly and significantly observed in project groups at other universities as well as in commercial software work. Different from other engineering disciplines it arises on the grounds of cooperation regarding a subject matter which is by no means sense-perceptible. Since this benevolent social faculty is just not based on personal connections I call it *superpersonal sociality*. To the extent to which it is developed it can be utilized consciously.

It is important here to recognize that for developing superpersonal sociality the presence of, and cooperation with, human beings is needed. It is a common experience among software experts that people who work alone on, or with, software could easily be led astray. They can be severely weakened socially, a very dubious result. Beyond the confines of the computer world it has been talked about a new professional pathological species called "hackers", i.e. programming or software people who spend most of their life alone in front of computer screens and keyboards, who do not take any substantial interest in the real world around them but have at the same time lost their capability for systematic intellectual or mental cooperative work. With Virtual Reality looming over the horizon another distressing example can be experienced when children are exposed to elaborate computer games (car racing, war games etc.). These aberrations are neither incidental nor completely restricted to Computer Technology. But nowhere other than in this discipline does it become so apparent that *we need human beings in our earthly lives (even in our professional lives), and much more so in a computerized world.*

From such insights there follow definite implications for university education, and these are certainly not restricted to Computer Science and Engineering. By the same token, and in face of Virtual Reality/ CyberSpace, this relates also to education in general, and this problem will have to be approached rapidly.

It is beautiful and moving to see the faculty of superpersonal sociality unfold but it may be surprising that this is so strongly connected to Computer Technology. In order to proceed here let us first ask whether the faculty addressed is really new for our experience. It appears to be so, at first glance. Whoever remembers his childhood in a vivid way will know, however, that all people have command over this faculty as an unconscious soul gift, during their first seven years. Personally I am glad that I have lived through this period of my life around the end of World War II, and in its aftermath in Germany. The whole life atmosphere was loaded for years with crime and adversary emotions. Children of my age had no choice but to live with it, and to imitate the adults as is customary in the first seven years. This had a dramatic appearance in the large cities where everything was in shambles and where people, due to the lack of residential living space, were crammed under very poor conditions. There was much fighting among street gangs of 6-8 year olds, there was a free training in all kinds of mean, bad, or malicious activities. But it was still customary (yet was not reflected in thought by the kids, of course) to play together with children who just before had been very bad. These early social relationships were not meant personally. They were superpersonal. Having individual relationships, subdividing the social environment into friends and foes starts only within the second seven years.

Now if you look around through the world for finding out where this living memory of early childhood, this rooting in the child world could still be strongly felt you will end up in just one country: in the US. As a principle there is still the habit alive, even among adults, to trust in everybody as long as this has not been forfeited. On this non-personal basis remarkable social activities arise in a setting where at the same time there is an overproportional longing for individual freedom and mobility, two features that have an antisocial impact. In this respect many people in Europe wish to establish the American example! It is this instinctive capability of superpersonal sociality in America which we equally saw arise in cooperative software development, which in turn - as we have discussed above - is an indispensable basis for software development in-the-large. In America we also find an extraordinary potential for a flexible, mobile thinking, as a heritage from the English language. Taking both aspects together we have then found a satisfying answer why America is the world center of software development, and, more generally, of computer progress.

6 What Has Mankind on the Whole to Do With Computer Technology?

As we are moving more and more into a computerized world we have seen in the previous section that people semi-consciously acquire a perception and an understanding for present and future organizational problems and of their relevance as they emerge from Computer Technology (compare the Dining Philosophers' Problem). New faculties unfold through experience with, and building of, computers and their software. The involved technical experts will gradually be enabled to utilize these faculties, for the better of their profession. (It is the experts who solve the problems.) However, how does Mankind benefit from the technological education which the small group of experts undergoes already? It is sure that all technical themes and problems with computers, like

- programming, testing, verification (i.e. whether a given program correctly realizes a solution for a computational, organizational, or other problem, or whether it executes correctly);
- the design of large programming or application systems (e.g. CyberSpace);
- the technical handling of software development problems which are incomprehensible in principle;

that these will all be left to the computer experts. It is already clear, however, that Mankind is gradually and increasingly pulled, through Virtual Reality, into temptations and seductions which have the same quality as those to which computer experts have been exposed. As indicated in section 1, people will be much more strongly affected by, and much less protected against, the coming challenges and temptations than the computer experts are nowadays. The foremost important task for Mankind will be to stand this technological onslaught.

In order to prepare for this unavoidable global perspective no help can be expected from treading one's way through conventional paths, neither in Technology nor in Education. As it was explained in section 5 this is inappropriate with respect to the nature of Computer Technology. It will be crucial to develop, shape, and intensify the new faculties described there which cannot be found in the past.

7 Overcoming the Drying Out of the Soul Life Through the Development of Higher Senses

Since Mankind will be unavoidably drawn into the stream of Virtual Reality, and of whatever will emerge soon, since only the computer people will benefit from the mentioned positive impact of Computer Technology, to begin with, what will Mankind learn through getting its share of Computer Technology, namely Virtual Reality, and what evolves worse from that?

Discussing the example of the first railroad trains we had recognized a loss of sensitivity, a drying out of the normal senses, resulting from confronting, and from suffering from Technology. We had then stressed that the resulting separation of perception and feeling allows Man to be really objective with respect to the world around him. Certainly the loss of sensitivity went hand in hand with a loss of perceptive intensity. But: Is this a necessary consequence of separating perception and feeling sphere? Are we on the way to eventually perceive the world like robots? Is it possible, instead, to extend our range of perception, to deepen these faculties, without becoming computer experts? In order to discuss these questions and to outline answers we will need an extended perspective.

Modern Technology, together with the modern scientific way of reasoning, has been created by *Leonardo da Vinci*. He is the Father of Modern Science and Technology, of all their modern forms. He always combined his mechanical studies with scientific concepts and conclusions as well as with experiments, the latter both for verifying conceptual insights and as a basis for deeper concepts and derivations. This led him to may groundbreaking discoveries, construction principles and methods. Since Leonardo's notebooks had mostly disappeared (some for many centuries, some have still not been recovered) it happened frequently that celebrated inventions turned out as re-inventions because shortly after the "invention" notes by Leonardo were found "incidentally" which described the "new" construction principles and details, dated hundreds of years earlier. An example from the beginning of this century is the invention of transmissions which have cogwheels with slanted teeth in order to reduce the loss of transmitted power, and even the noise of the operating cogwheels. Leonardo's notes showed exactly this construction, plus the explanation of the principle behind and its effect. How did Leonardo reach his insights, how did he get to his ideas and technical constructions?

The development of consciousness through an inner equilibrium process

Many books have been dedicated to the last question. They have discussed his phenomenal strength of perception, his purportedly abnormal visual sense. From studying Leonardo's notebooks one derives a good evidence that these assumed special faculties must have been developed gradually through the course of his life. This occurred along with a biographic specialty: He is found moving seemingly erratically in his outer and soul life, between two poles. One of them is the formation of the modern scientific and technological way of thinking and working, the other one can be seen as a revolutionary approach to the art of Painting (and, though less prominently, also to Sculpture). The revolution can be summarized by stating that the outer movement and inner motion displayed in his paintings and drawings, the life, the tragic, the dramatic element completely grow out of the inner life of the persons depicted. No longer were a divine or religious background or cause needed. Leonardo has transformed Painting into an art which in this sense has become *independent*. A very good study example is his Last Supper.

In parallel to his discoveries in Science and Technology he lays the ground for Modern Painting, through formulating or refining scientific laws concerning his theory of the Light and the Dark *(Chiaroscuro)*, the principles of mutual amplification of expressive or soul life features through contraposing contrasting elements, objects, moods etc. *(Contraposto)*, the different aspects of *perspective (geometric-linear, air, color perspective)* (see [Leonardo]). It was not only a theory. Leonardo saw these qualities. Up to now in Physics, we are solely concerned about the (abstract) geometric space. Nobody (except Goethe in a preliminary form) has so far picked up the concept of a *color space* in Science. Only the impressionist painters saw it, and lived in it, as a reality.

Progress in the scientific technological direction frequently entail novel insights for Leonardo into the laws of Painting, and vice versa. On the other hand his outer life, and consequently his professional career, appear somewhat ragged. Like a pendulum he moves between the different poles of activity. Instead of completing commissioned paintings he would often be found thoroughly absorbed by studies of new mechanical constructions or by Comparative Anatomy (which he invented as a discipline). Instead of engineering and building war machines for cracking city wall systems, he was tied up with drawing studies, or with geological theories (like about the formation of mountains). This was all but useful for his career, and it made him intensely lonely in his soul life. Nevertheless he pursued this extraordinary path because he had a multi-faceted feeling about connections between the different poles of his activities. While on the surface Leonardo showed a seemingly emotional and unstable professional development without strong perspectives, while he lacked a real business instinct (which his younger colleagues Raffaello and Michelangelo certainly exhibited, in contrast), by following his inner path he made an overwhelming contribution to human Culture, by becoming the Father of Modern Science and Technology as well as the founder of Modern Painting.

Leonardo's development is most adequately described as an *inner process of equilibrium finding, of finding and maintaining an unstable inner equilibrium.* There is an analogy in everybody's life development. As a baby everybody learns gradually to get upright by finding and maintaining a (literally) unstable equilibrium. After this has reached a level of perfection in which the toddler is able to move freely, to walk, he will soon forget the pain and effort which this learning procedure meant for him. As adults we have to make a conscious effort (or experiments) to get aware that we are still permanently in an unstable equilibrium state (except when we are lying in bed).

"This outward process of equilibrium finding is in correspondence with an inner process of getting upright. This latter one is at the same time a process of *consciousness formation.* This can be derived from the fact that after the small child has learned walking freely, *and only then*, he will learn to **speak**. Indeed, if one observes this inner process in some detail it essentially is experienced as a *groping for an equilibrium in the world of concepts, words, and of their contents.* This is just the way how many adult people remember their earliest childhood. (On a different level there is still a similar experience whenever adults have to grasp for words or expressions which are supposed to really make a new idea or insight clear to themselves or to others, to make the insight *conscious).*"

If we understand an inner process of equilibrium finding as a process of developing consciousness then we can get an immediate understanding for Leonardo's inner development. As already mentioned at the beginning of this section researchers stated that he possessed an abnormal, an abnormally intensive vision capacity. For certain exotic humming-birds he had e.g. drawn the wing feather motions in flight although these are so fast that nobody can really perceive them. Only after cameras could be built which would allow for several thousand shots per minute it turned out that Leonardo had "seen" everything correctly. Consequently, as a sign of scientific poetry, it was concluded that he possessed an extremely (physiologically) "strong" visual nerve. In this way it was neglected that this fantastic capability developed only gradually in the course of Leonardo's life which excludes a physiological interpretation, let alone that such an explanation would still leave everything as a mystery. Instead, we have here a very distinctive example for a developing (higher) faculty of perception through which it is possible to capture a motion in its own quality, be it a gesture in its expressive value, or the dynamics of the forces in streaming water. In the course of development this faculty becomes a higher sense which operates increasingly independent of the Sense of Vision. I will call it the *Sense of Motion*, using the term as it was introduced by Rudolf Steiner [Steiner1]. In the same quoted book other higher senses are characterized. This goes beyond the scope of discussion here. Instead, our focus will be on the principles and processes through which Mankind is to acquire these senses, and these principles are really in effect as we will see below.

As Leonardo moved inwardly between the arid realms of Mechanical Technology and experimental Science and, on the other side, the living pictures behind his paintings and sculptures he *consciously* developed higher senses in a life-long effort. This set the stage not only for the scientists and artists to borrow from his example and methods but ever since western Mankind has been embedded into a corresponding process of general education (which is experienced semi-consciously). As one can read from Leonardo's writings he was able to directly perceive, to "see" the active mechanical forces as well as the sculpturing life forces which are e.g. behind the plant growth. He handled them consciously, by setting up novel mechanical constructions and by representing them in his paintings (like the Mona Lisa). Similarly Mankind acquires a semi-conscious relationship to these forces. This yields an *instinctive* feeling for their presence and quality. In contrast to a consciousness development Spiritual Science [Steiner2] calls this a development of a soul faculty, of a soul member.

The general education of Mankind

Mankind does not consist of mechanical experts at all. The experience of the Industrial Age comes only centuries after Leonardo. Yet broadly speaking, people have acquired through modern school education the potential of sober thinking and impartial perception, similar to Leonardo who did this as part of his life task. In either case such a process needs a person's individual initiative, through a conscious or semi-conscious effort. Thus *these faculties grow out of people's own strength.* (Leonardo even described the principles of his inner path.)

Through Leonardo's groundbreaking effort on behalf of Modern Science Technology and Art, and along this line through the work of so many scientists and artists since, a path was prepared for outstanding representatives - scientists like Newton, philosophers like Kant - to find a substantial degree of reception for their own ideas.

As a result of successfully pursuing an unerring scientific observation and objective reasoning (as part of the inner equilibrium finding process) Leonardo was able to make Painting an independent art. Beyond the characterization given above I call an art form *independent* (or *absolute* in case of Music) if the dramatic life coming to expression through a work is arising completely out of its own elements. In Painting as well as in Drama it arises from the human beings presented, or acting, not any more from allegoric divine connections or relationships. In Music the dramatic life comes from the treatment of the (instrumental) voices or parts as autonomous gestures, subjects, or entities. Drama became an independent art through Shakespeare, Music reached this stage through Beethoven.

After clarifying concepts we want to elaborate how the equilibrium principle was unfolding in modern history. The first observation is that electric phenomena and processes although having been present long before are identified as subjects of scientific interest, as phenomena in their own right, just during the second half of the 18th century. But this happens coincidentally with Music being established as an independent art form (this period shaped by Haydn, Mozart, Beethoven).

Mechanical objects and forces exist, or are effective side by side, and in physical space. (Even in case of fluids two streams cannot be merged without turbulences occurring. It takes energy to overcome the resistance of the forces connected with the streams. The resistance reflects a tendency of the mechanical forces to work in separation, or even to fight each other if forced into confrontation.) The same is true for Painting. Here the depicted elements are also arranged in space to coexist, to cooperate. They do not penetrate each other. A bridge like the one between Painting and Mechanics can again be found between Electricity/ Electrical Engineering and Music. In musical performances the parts or voices sound at the same time, we observe their interpenetration, and it is through this effect only that harmony and lively rhythmic structures are created. Compared to other forms of art, changes of mood, of the expressive character within a composition may be incredibly abrupt, extreme, immediate, and unexpected. Correspondingly electric phenomena and processes exhibit an extreme volatility, sudden and extreme changes (e.g. electric discharges in lightning). Also electric currents interpenetrate each other without any loss of energy, without any appearance of turbulences. Otherwise Kirchhoff's laws would not hold.

Finally we observe that during the same period when Computer Technology arose, i.e. during the first half of the 20th century, a new form of art emerged which is called *Eurythmy*. It has been created by Rudolf Steiner. It is an art of motion, of dynamic gestures. Like in Music or other performing arts, what is expressed in Eurythmy has to be anticipated by the performer, an inner gesture has to be initiated first. Different from Music this inner gesture is a direct expression of inner life, it is not really conveyed through sense-perceptible impressions (e.g. audible ones in Music). The gestures if

Development of Soul Faculties through General Education of Mankind
(Principle: Inner Equilibrium between Technology and Art)

Century	Art	Technology/ Science	Basis for Equilibrium Processes
15th/	**Painting/**	**Mechanics**	sensible elements
16th	**Sculpture**		side by side, in space lasting
18th	**Music**	**Electricity/ Electrical Engineering**	*only temporarily* sensible elements, in space and time interpenetrating objects volatile, quick changes
20th	**Eurythmy**	**Computer Technology ("Magnetics")**	non-sensible elements, beyond space, in time mutual encounter of objects education towards super-personal relationships

Figure 6

performed this way, stimulate an inner experience of a new quality which is approximately described as inner, soul warmth. Such experiences can in turn be expressed through specific Eurythmic gestures, in such a natural way that if addressed to another person, this would convey to him, even stimulate in him the originating experience. (He would inwardly do the same gesture.) So Eurythmy becomes an art for a direct and most intimate communication from soul to soul. Since inner warmth is typically expressed through human encounters Eurythmy is predominantly a social art, more than Music, much more than Painting. The objects, the elements are the most inward human features and qualities. Thus they are the least perceptible by the "normal" senses.

Starting with Painting and Sculpture where the objects are sense perceptible, pictorial, and lasting, even solid; continuing with Music where a sensible experience occurs only as long as one listens to a piece, which is not outwardly lasting and supersensible otherwise (a Beethoven symphony exists, or can be lived through also when it is not performed); we end up with Eurythmy as the most inward form of art. Eurythmy is not yet an independent art. It is still closely tied to Speech and Music where it would intend to express and amplify the contents through gestures (similar to an opera where the music represents and intensifies the dramatic contents as given by the verses). So far there are a few examples of the future role of Eurythmy as an absolute gesture art, e.g. there are gestures which are definitely and intimately the expression of soul moods not otherwise expressible.

What has been said about Eurythmy has its direct correspondence in Computer Technology. Hardware processes are stimulated by electric processes. A computer needs electric power, through sockets. However, computer processes are not electric by nature. (Thus there is no electric or electro-magnetic model for a transistor, the basic functional element. For physicists the functioning of transistors is a dirt effect.) Hardware and software processes are two main emanations of the magnetic. We still have to learn how to perceive magnetic *processes* and to treat them as scientific objects. (In Physics there is not even an adequate concept of a *process*, and magnetism is studied only in its static appearance or as electro-magnetism.) This would create a new area in Physics which I call here "Magnetics".

Computer Technology is not an independent discipline as long as it is tied to electricity. This connection reflects back on all present concepts of hardware design. (The idea of switching circuits stems from Electricity.) In the future, as I am convineed, people will learn to perceive and handle magnetic processes and forces, and then computers will be conceived and built which are completely dissimilar to the present ones.

From the discussion on the virtual nature of software (see sections 2 and 5) it is immediately clear that compared to mechanic or electric processes, computer software processes are the least graspable. They are supersensible, and otherwise incomprehensible in principle.

Finally we see a strong connection between Computer Technology and Eurythmy by recalling from section 5 that through the development of software systems - which is a group effort - a faculty of superpersonal sociality is formed and practiced. Due to the virtual nature of software there is a particular need for being in close (work) contacts with human beings. For university students it frequently turns into a sad experience that books or other forms of documentation (including own notes) are by no means sufficient teaching material but learning occurs mostly through intensive discussion and cooperation with fellow students. (This is quite different in Mathematics or in Science.) In addition the progress of a project as a whole is only dynamically shaped and determined, it is not known by anybody in advance. (This is in contrast to classical Engineering disciplines.) In this sense Computer Technology is the most socially related technology. The discussion above is graphically summarized in fig.6.

Steps in Modern Education of Mankind

We had concluded that Computer Technology, with the arrival of Virtual Reality, will impact and change everybody's life situation at a quickening pace. The problem of standing Computer Technology will be more and more serious, facing the danger of losing the human element in each individual life. Earlier in this section the question had been asked how higher faculties of perception and of strengthening inner capabilities could be acquired by Humanity although so far they are only semi-consciously learned and practiced by computer experts.

In a large outline we have sketched the development of modern Science and Technology as it is connected with the development of modern Art, and we have focused our attention on a process of finding an inner equilibrium into which western Mankind has been immersed since nearly 500 years. (We recognized that through Virtual Reality the remainder of Mankind is now gradually becoming involved in technology as well.) We have further observed that during this period there has been a steady line of development, in Technology as well as in Art, from the visible, the sense-perceptible, towards ever less sensible and supersensible objects and connections. Mankind has to confront the world in a more and more inward way, thus gradually building inner capabilities and awakening higher senses for standing the diverse harsh technological challenges. For establishing an adequate education (e.g. school education) as well as respecting the requirements and insights discussed in sections 4 and 5 it is imperative to know the modern soul initiation and education principles which have to rely on every person's own initiative and strength. The time has come now!

The new faculty of sociality will enable Man to take the earnest resolve of fully devoting work for the well-being of other persons (not just for abstract objectives), without sticking to sympathy, antipathies, or prejudices of any kind. Superpersonal sociality is the most relevant soul capability among those which are to constitute what is summarized under the term Consciousness Soul in Spiritual Science (see [Steiner2], the chapter on the nature of Man). School and life education in the Consciousness Soul era will have to take Computer Technology serious, in light of all issues discussed. As a first consequence the current curriculum has to be reworked. So far an introduction into hardware design (of switching circuits) and (user level) programming is offered in order to give the students a basic "understanding" of the computer. This is misleading (having in mind the incomprehensibility in principle), and otherwise it would mostly address the (rare) technically talented people if only it was not so elementary. (In practice the students frequently outperform their teachers thus find the instruction boring.) Utilizing the extreme fascination of Technology should by no means be considered: firstly because of unforeseeable risks regarding addiction, of being patronized in many life perspectives, secondly because the young people would be educated to be "hackers" (as we described them in section 5), i.e. software "cripples".

With the Dining Philosophers' Problem we have discussed a very difficult key problem for operating system design (as well as for the broader scope of distributed systems), and I have reported that every kind of audience, experts or non-experts, understands it on the spot, and is even intrigued. It has also been made clear how such problems educate us into a flexible, living thinking. Such problems can, of course, be identified in human organizations, in administrative and economic contexts. But only in the computer software context a technically sharp solution is required.

Our experience in High School and university education shows convincingly that starting computer education from this problem perspective meets a lasting attention, it even triggers technical questions and engagement, both by talents and "normal" students.

Taking into account the relevance of finding the inner equilibrium for the development of the higher senses leads us into a second direction. As Computer Technology and Eurythmy are related poles for the equilibrium process, and particularly important for developing superpersonal sociality, it will be crucial over time to introduce Eurythmy into the public school curriculum. (So far Eurythmy is a compulsory class at all grades in Waldorf Schools.) We will restrict ourselves here to these few hints. A more elaborate discussion would be beyond the scope of this paper.

Future perspectives

Considering again the rising of modern Technology and Art and their impact on the soul and consciousness formation, it is obvious that this comprehensive and global development could not possibly have been thought out by intelligent individuals. Their "provably" correct contributions are based on traditional concepts and extrapolate from them. Is it not moving that the formation of modern Technology and Art, stemming from Leonardo's life task, appears in its deep wisdom as if helped and guided by good Higher Powers? How could one otherwise conceive what looks like a "red thread" leading through all scientific/ technological or artistic efforts of so many individualities, over so many centuries, without these ingenious personalities being conscious about the grand design and the coherence behind?

Working with the insights described in the previous sections has also led us to be aware of the activities of adversary powers. We have already stated that with our current inner strength we will have a hard time to escape the looming threatening dangers and temptations to our inner Self. Given that everybody instinctively is hesitant to willingly be exposed to inner risks or temptations this frightening path into the future is nevertheless unavoidable, due at least to the vital economic interests behind Virtual Reality/ CyberSpace. In an incredibly intensified effort (as compared to entering the TV age) there will be a gigantic drive into Virtual World. Whoever is familiar with the economic decision processes knows that chief executives, boards etc. make many crucial decisions instinctively, they have a kind of dream-like consciousness regarding the economic circumstances and consequences of their decisions, sometimes they even act as if asleep. In contrast, the promotion of Virtual Reality appears like carefully planned on a long-range perspective. It looks like born out of a huge superhuman, strategic intelligence. Those powers to whom such an intelligence is ascribed are called Ahrimanic in Spiritual Science [Steiner 2]. The Ahrimanic temptations, however, invoke an instinctive resistance towards keeping an inner balance as long as people are not too weak. Without these evil powers pulling us down we would certainly not take any reasonable effort to overcome traditional habits regarding consciousness, feeling, will.

The real nature of what is presently Virtual Reality will only reveal itself in the future, and I strongly feel that the wise Higher Guides of Mankind - who obviously leave us even the freedom of giving away humanity - will be further present during the stages of Consciousness Soul development. Nevertheless the educational task for Mankind, as much as for each individual, is so trying that pessimism is easily at hand even if a large number of individuals had already taken the resolve to go through the pain (which is not really the case yet). However, those who have been into school education for a longer period of time know that the generation of people who were born since ca. 1970 are to a certain extent prepared for everything to come, for meeting the future changes and challenges addressed. They have made some headway already towards superpersonal sociality as well as towards the novel flexible, living thinking. A paradox as this may appear to be at first glance it gives us some hope for finding good company on our path, and a good ground for our work. To take up tasks for a whole era of Mankind with these young people, to shape and direct with them what will emerge from the experience with Virtual Reality and CyberSpace-like systems is deeply encouraging and exciting.

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