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# Simulating the Mind

## A Technical Neuropsychoanalytical Approach

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## Preface by a Computer Pioneer

The ENF (2007) forum was about new approaches to information processing using a bionic approach by attempting to copy the principles of human information processing. Clearly, current information processing can already do many things automatically which previously could only be done using human intelligence. However, a lot of human intervention is already required before information technology yields results, not only in providing the machinery on which the processing should run, but also for programming the task in question.

In this regard humanity underestimate the by now omnipresent computer; this tool is not only – as it appears – a typewriter also storing and copying. It is intimately interconnected with its environment, with the institutions in which it operates.

Computers work with models. For humans, the use of models is also a basic feature, a "built-in facility" of human thinking, of our dealing with the world. We do not even have to learn the concept of a model. It evolves automatically, a set of common features is remembered and a name can be attached to memory content. However, what sometimes occurs with models is that the difference is neglected and the model is mistaken for reality. This effect is supported by not giving different names to reality (the real "object") and the model.

We use many kinds of models. For that matter a name for a concept is a model: the content of which we build up through experience and thinking, by reading and contextual observation. It is thus evident that one can model everything and, given a model of something, it can immediately be programmed on a computer (not necessarily in a brief period of time).

In the scientific borderland that the ENF encompassed, the distinction between reality and model is by far more important than in individual fields. Equating reality and can lead to very wrong conclusions. Massive redundancy in communication is by far preferable to misunderstanding and errors.

The question of computer consciousness was also raised. The approach in the past was to look inwardly and mimic human consciousness. It obtains input information and, supported by memory, derives output information which triggers action. That is, of course, precisely the structure of a computer – how could the pioneers have done otherwise? However, what have we achieved? The computer could act like a human[1]. Yet we have no basis for thinking that we have created computer consciousness. Our programs have made computer consciousness unnecessary.

However, I wish the authors good luck in their attempt to implement a first hypothesis of computer consciousness.

*Heinz Zemanek*

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[1] and easily pass the Turing test – which I consider an error in thinking by Turing, a logical mistake such an accomplished logician should never have committed.

## The Cooperation Between Siemens and the TU Vienna

A good two years ago Professor Dietrich from the Institute of Computer Technology at the Vienna University of Technology approached me with an intriguing idea. Why not apply the findings on the human brain, its method of thinking and learning, to computer models and software solutions for industrial automation engineering?

At the Automation Division at Siemens Austria, we are involved in many forward-looking concepts such as the development of the digital factory. It was therefore only logical that Siemens should explore this idea from the Vienna University of Technology in greater depth.

Automation and automation processes are developed on the basis of a multitude of increasingly intelligent sensors and actuators, integrated and interconnected by means of software. Consequently, all components are networked and communicate acquired "knowledge" in centralized and decentralized control units. This interplay is reflected in manufacturing and processing sectors with ever greater complexity. Processes are determined by increasingly complicated algorithms.

These advances in automation give rise to the questions: can these models be explained or described by the findings that have been made on how the human brain functions or by models of the human brain and could we also derive simplifications from these findings? The question is one that we wrestle with daily and that is what determines our approach in research and development.

As Siemens automation experts, we voiced our clear support for close cooperation in staging the conference week 2007 in Vienna (npsa, ENF, IEEE INDIN, industry day) and participated in it wholeheartedly. Helmut Gierse, the former director of Siemens Automation Engineering worldwide, shared our interest in the interconnection between these fields and responded promptly to the request for support. He demonstrated his foresight, by continually pushing for strategic derivatives to be found in this field for this change of paradigm.

What underlies the challenge to learn? This question was answered in the interplay of time and content at the conference of neuropsychoanalysts and through a partnership with the world's top researchers on the subject of brain functions. I believe this approach lent a valid scientific base and reliability to the structural organization of the arrangement for cooperation with the Vienna University of Technology, the host of the joint forum.

We engineers wondered how we would even understand this "medical" language used by the neuropsychoanalysts. A model of the brain's structure based on the ideas of Sigmund Freud provided the "consoling" answer to that question and allowed us to lay the groundwork for an intelligible discussion for the varying scientific disciplines of the analysts and the engineers.

Siemens agreed to provide financial and organizational support for staging the conference week. The initial budget was straightforward and the number of participants was clearly defined.

The announcement of a conference of psychoanalysts in Freud's home town was well-received internationally due to the overarching theme and became a genuine challenge for Siemens in Vienna. We were likewise aware of helping to bring about something new, something revolutionary with the foundation laid by the Vienna University of Technology. In addition, we definitely wanted to offer the visitors coming in from around the world not only new insights from the lectures and workshops but also a professional event and a memorable stay in Vienna.

To ensure a good conference of practical value, we at Siemens Austria invited excellent and visionary guest speakers on production engineering ("Trendsetting Automation for the Entire Value Chain") and on process engineering ("Trends and Innovations in Process Innovation"). They presented the world's most advanced research findings in these fields and provided food for thought to the participants in the IEEE INDIN conference, all of which was intended to smooth the way from research to application.

We thank the organizers and initiators from the Vienna University of Technology for allowing Siemens to contribute actively to this subject. We took great pleasure in co-organizing this event. The praise voiced by participants from many countries is compelling indeed.

*Dir. Ing. Wolfgang Morrenth*

# Preface by the Editors

The attempt at modeling and finally simulating the human mental apparatus is a sublime goal and a real challenge. The authors aim to attain this goal with the cooperation of engineers and neuropsychoanalysts.

This book contains thoughts and ideas of a lot of people who work in rather different fields. We are happy that we managed to bring them all together and unite them in this book. Psychoanalysis and engineering have a lot to contribute to each other and we hope that this book continues to foster cooperation between these two disciplines. A first milestone was the “Engineering and Neuropsychoanalysis Forum (ENF)”, of which we have included the full proceedings. It was a day full of fascinating presentations and fruitful discussions between representatives of psychoanalysis, neuropsychoanalysis, neurology, engineering, and many other fields. However, the ENF also revealed that it is likely that when two persons from two different fields have a conversation, that though they may believe that they understand each other, they in fact do not and also cannot.

We packed all the video recordings of that day onto three DVDs, so that not only the participants have access to it. Another reason is to be able to learn – in retrospect – from the obvious misunderstandings for the next meetings.

A further step was to issue a Call for Participation, which brought forth more than twenty publications, of which ten are included in Part III of this book.

Engineering and psychoanalysis at first sight do not have much in common; they have different ways of working and use a different vocabulary or – even worse – the same vocabulary, but with different meanings. We wanted to build a bridge between these two and we hope that this book will afford researchers a basic understanding of each other’s discipline and an idea as to how cooperation may be deepened. If we manage to employ psychoanalytical findings in engineering research and the other way around, then the book was well worth the effort.

We want to thank the HarrisonMcCain Foundation for supporting author’s cooperation. We strongly want to thank all authors for their contributions and hard work to make this book successful. We also would like to express our gratitude to the ENF session chairs and all attendees, and all who encouraged us afterwards to continue, or submitted suggestions for further progress. In particular we want to thank Elisabeth Brainin, Tobias Deutsch, Dorothee Dietrich, Harald Hareter, Wolfgang Jantzen, Friedrich Kamm, Roland Lang, Josef Mitterbauer, Brit Müller, Brigitte Palensky, Peter Palensky, David Olds, Marianne Robert, Charlotte Rösener, Mark Solms, Samy Teicher, Anna Tmej, Mihaela Ulieru, Rosemarie Velik and Heimo Zeilinger for their constructive contributions and vital remarks which went far beyond their duties as chairs or authors. We appreciate all insights into scientific disciplines that may appear foreign to other researchers. In fact, putting this book together showed clearly what our research field is all about: working cooperatively on the same task and gaining mutual benefit from the results.

*Dietmar Dietrich* *Georg Fodor* *Gerhard Zucker (né Pratl)* *Dietmar Bruckner*

## How it all began …

In 1998 I was told that a child in my neighborhood was hurt in an accident with boiling water in the kitchen. The injuries were so severe that they would be visible for her entire life. At this time my area of research, building automation, concerned topics like energy efficiency, security and comfort, but not safety. This event made me aware of the lack of effort put into safety. I took the precise scenario of a child in danger in the kitchen environment as the basis for a ground breaking research project, namely the perception in building automation for recognizing potentially dangerous situations which require adequate protective measures. Nanotech as well as modern web-cams should help to make it possible to install hundreds of smart, distributed sensors in the living environment, for example in kitchens, to allow a system to perceive precarious situations.

One of the major boundary condition of building automation was and still is the necessity of using inexpensive sensory equipment instead of very costly industrial cameras. Sensors should be diverse and complementary, and the system should be able to use sensors which will only arrive on the market in 10 to 15 years. The whole electronic section must be kept simple. Everything must be plug & play, which means that the network must be able to incorporate additional components without configuration requirements. To achieve this level of interoperability, further research in the areas of embedded systems and software compatibility is required.

In embedded systems, when considering a bionic approach, the diversity of sensors and their interconnectivity are highly relevant. Unfortunately, artificial intelligence, cognitive science, and related fields are still hardly able to transfer the principles of intelligence occurring in nature into technical models. As the market also does not require such systems *now*, there is no indication of a shift in the way of thinking; no new developments may be expected in the foreseeable future. In this situation the question arises: which chance do we have for using the intelligence occurring in nature as a model for developing technical solutions?

In 1998, while searching for solutions for principles of intelligence I had a crucial get-together: I met Helmut Reiser, professor in the field of special education in Hannover, Germany. We discussed how humans perceive and recognize their environment. Mr. Reiser explained in detail recent research results from the fields of psychology, pedagogy, and psychoanalysis. He told me that humans associate sensory images; however association is just a small piece of the puzzle. The whole procedure leading to perception is much more complex than was previously thought. In all sensory modalities only characteristic features can be perceived. Via the perceived features, images already stored in memory are associated with each other. With the help of the characteristic features and the associated data from memory the mental representation of the perception is constructed. Therefore, humans can only recognize what they can associate to images which have been internalized previously.

The discussion with Reiser lasted several days until I came to the conclusion that bionics in the area of artificial intelligence has to follow completely new paths. Back in Vienna at the Institute of Computer Technology I found two PhD students – Ms. Clara Tamarit and Mr. Gerhard Russ – who I could convince to assist me exploring new ways for automation. Soon we had the support of "diploma" students.

Being a chip designer, it was clear to me that I would have to utilize a top-down design methodology to have a chance of success. Unfortunately, this approach was incompatible with contemporary results from artificial intelligence as well as psychological and pedagogical sciences. Furthermore, these sciences did not possess a technically implementable unitary model of the mental apparatus at hand, just a collection of psychological views of various schools which mutually reject parts of each other's concepts. Computer engineers need consistent models; ambiguity is not compatible with computer programming. So, how were we to proceed?

My wife Dorothee, a psychoanalyst in training, gave me the decisive hint: she told me of two well known researchers in the field of neuroscience/psychoanalysis/behavioral neurology: Oliver Sacks and Mark Solms. She also put me in touch with a Viennese psychoanalyst, Thomas Aichhorn, with whom I could establish a fruitful relationship. It was him, who then introduced me to Elisabeth Brainin, a neurologist, psychiatrist and training analyst. This connection was the key to a breakthrough. Elisabeth and her husband Samy Teicher – also a psychoanalyst, – became our permanent consultants and reviewers and helped us develop our unitary concept. That was the time of the 2nd generation of PhD students, of which one after another completed their thesis: Gerhard Zucker (né Pratl), Dietmar Bruckner, Wolfgang Burgstaller, Charlotte Rösener, and Brigitte Palensky.

In the early days of this second phase my wife Dorothee introduced Georg Fodor to me who is also a psychoanalyst and a colleague of Mark Solms. Things started to speed up. I was convinced especially by Elisabeth to visit Mark in Cape Town. An opportunity arose when I gave a guest lecture in Pretoria. I will never forget the meeting with Mark. We soon came to the understanding that our views and aims were very similar in that the human mind has to be investigated using scientific methods and the psychoanalytical model.

Subsequently Mark and our group met regularly, which helped us and specifically our project manager at that time, Peter Palensky, to be very successful. He was able to bring the international IEEE[2] conference INDIN[3] to Vienna. At the same time Mark and Georg where also trying to bring the international npsa[4] conference to Vienna close to the timing of the INDIN conference. This enabled us to hold a joint forum called "ENF[5] – Emulating the Mind" on July 23rd, 2007, orga-

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[2] Institute of Electrical and Electronics Engineers

[3] Industrial Informatics

[4] Neuropsychoanalysis Centre

[5] Engineering and Neuropsychoanalysis Forum

nized by Gerhard Zucker and his team. At this point I have to express special thanks to Wolfgang Morrenth, head of Siemens A&D (Automation and Drives), who believed in the necessity of a paradigm shift in automation and enabled us to realize our ideas for such a forum. With his help the company Siemens sponsored the enormously costly four-part-event for seven days. The npsa conference came first followed by the joint workshop between neuropsychoanalysts and engineers. Then, right after the ENF, the IEEE INDIN conference was held followed finally by the industry workshop with its respective activities. Siemens had surpassed themselves.

The ENF was a great success. One could feel the atmosphere in the hall. It was recorded by several cameras; a set of DVDs was produced. It was completely clear to me that the workshop has to finally lead to the compilation of a book containing more than just the proceedings of the workshop. We tried to include as many discussion results and new insights achieved at the ENF as a result of this forum. The decision to edit this book was the moment the third and current phase of the project was born. Suddenly, many things became clear, but also led to much more complicated questions.

As a consequence we enlarged our team. It now not only consists of engineers and psychoanalysts as consultants, but also of regularly employed psychoanalysts, Brit Müller and Anna Tmej. They are working together with the third generation of PhD students of this project – Tobias Deutsch, Roland Lang, Rosemarie Velik, Heimo Zeilinger, and Tehseen Zia. And we – engineers and psychoanalysts – started understanding each other.

I would like to express my gratitude to those, who contributed to the very difficult first steps of our common path towards a unitary model of the mental apparatus as basis for a new field of research. Reflecting on my experiences with the first steps taken into our new field I found a better understanding of the great achievements of Sigmund Freud and of Mark Solms. Freud knew more than a hundred years ago that the mechanistic way of thinking is not applicable in information theory. This insight has still not reached many IT-engineers (the error will be explained in detail in later chapters). In my point of view Freud's greatest achievement was not to think differently than most of his colleagues, but to stand so firmly and consistently to his convictions. I see Mark Solms' greatest achievement in succeeding to bring together two faculties hostile to each other, neurology and psychoanalysis, and in starting an association with members from both fields, the npsa.

I am curious whether we will succeed in establishing an international cooperation of engineers and neuropsychoanalysts. The ENF workshop raised hopes, but also showed the enormous ditches and reservations and all the diverse sciences' peculiarities.

There is a lot of work still to be done.

*Dietmar Dietrich*

# List of Authors in Alphabetic Order

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| Dietmar | Bruckner | Vienna University of Technology, Austria |
| Andrea | Clarici | University of Trieste, Italy |
| Tobias | Deutsch | Vienna University of Technology, Austria |
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| Heimo | Zeilinger | Vienna University of Technology, Austria |
| Gerhard | Zucker (né Pratl) | Vienna University of Technology, Austria |

# Organization of the Book

The editors claim that the human brain and mind can be seen as objects which can be investigated with scientific principles. The findings can and must be applied in engineering. One cannot proceed on this path without taking the knowledge of psychoanalysis, the scientists concerned with the human mind, into account. However, their models need to be analyzed from a technological point of view, in cooperation, naturally, with psychoanalysts. And vice versa, the editors are convinced that engineers and computer scientists can pass on knowledge about modeling and synthesis to the science of psychoanalysis.

This book documents the attempt at the "First international Engineering and Neuropsychoanalysis Forum (ENF 2007): *Emulating the Mind*" in working out a unitary view on how to proceed in simulating the mental apparatus.

The book is organized in four parts in order to highlight separate views and to incorporate the contributions of various authors:

Part I constitutes the theoretical base, worked out while strictly following the principles of natural science, to which later contributions will refer. Additionally, major research results from the past five years are presented. They were also presented in abbreviated form during the (ENF 2007) "*Emulating the Mind*", incorporating results from the speakers and their co-authors.

Part II is formed by invited publications that represent the content of the ENF 2007 forum and the summaries of the discussions on that day.

Part III contains strongly reviewed publications collected in a Call for Contributions, representing the reactions to the ENF 2007 forum.

Part IV comprises explanations for engineers and psychoanalysts in a glossary-like fashion. It contains basic explanations of terms to simplify understanding for readers with a different scientific background.

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# Part I  Theory

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| | | |
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| Elisabeth | Brainin | Vienna Psychoanalytic Society, Austria |
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| Gerhard | Zucker (né Pratl) | Vienna University of Technology, Austria |

# 1 The Vision

The approach to developing models described within the following chapters breaks with some of the previously used approaches in Artificial Intelligence. This is the first attempt to use methods from psychoanalysis organized in a strictly top-down design method in order to take an important step towards the creation of intelligent systems. Hence, the vision and the research hypothesis are described in the beginning and will hopefully prove to have sufficient grounds for this approach.

When bringing together two fundamentally different scientific disciplines such as psychoanalysis and engineering, it is of great importance to clearly define the theoretical basis. The first phase of the project revealed very quickly that not just the methods, but also the vocabulary are completely different. Communication was challenging for all partners involved. In order to proceed scientifically it is inevitable that one first defines the building blocks to be used later on to build the model.

The developments in physics, material science, or chemistry are enormous. The packaging density in highly integrated circuits is a very good example. In the 1970s only 10.000 transistors fitted on one chip, in 1990 already 1.000.000 and today we have 100.000.000 transistors on one die, a number far beyond consideration in the 1970s (Khan 2007). Another example, although less spectacular, but of great interest for the market, is home and building automation. Hardly any office building can be found in the western hemisphere that does not utilize any modern building automation communication systems – fieldbusses. This part of automation has grown to a billion dollar market (Loy et al. 2001, Sauter et al. 2001), since the requirements on home and building automation are continuously rising. It may be assumed that 50,000 computer nodes (embedded systems) need to be installed in a large building today. These nodes have to be designed, integrated, and maintained. None of today's tools has sufficient efficiency to deal with this incredible number of network nodes and the information they provide in a corresponding cost efficient way.

Countless other examples could be listed here from the areas of motor vehicles, airplanes, trains, or energy technology, especially where safety and security considerations are of critical concern. Automation technology will eventually be integrated into all areas because "smart systems" are being increasingly integrated into every kind of imaginable object. This implies on the one hand an enormous amount of data that has to be processed, on the other hand that we will be incapable – considering today's technology – to properly process and interpret the accumulating data, let alone efficiently, and comprehensively. Contemporary technical systems are far less intelligent than they are required to be in order to interpret data as well as humans. Just a simple example from the area of recognizing scenarios: Behavior of people can be perceived and recognized via a camera. What problems may be anticipated? The videos from inside and outside of the airport are analyzed by specially trained security staff sitting in front of monitors in the security room. Automating this process is not trivial, but needs to be technically solved. How to implement it is a different question that nobody can yet answer: first of all the trade union blocks the utilization of such systems because they could be used to observe the personnel. That is to say, there is a clear distinction between purely automated surveillance and surveillance by humans[6]. Or another example: During the preparation for the Olympic games in Greece every newspaper featured an article on the huge troubles caused by the software for monitoring the facilities and events , mainly due to the unexpectedly high costs. The reason also lay in the complexity of interpreting scenarios.

Technology needs methods to mathematically describe algorithms, which have not yet been discovered. One way to solve that dilemma is the so-called bionic approach. To give an example of one of the greatest successes of Bionics, the technical modifications which lead to the development of the A320 from regular airplanes like the A31x shall be described: the Airbus A320 was the first plane worldwide to use fly-by-wire control technology, which enabled a reduction of fuel consumption by 27% and more. With this technology it was possible to hold the plane in an instable position – horizontally flat. For several, mainly legal reasons, it took Boeing quite a while to catch up; however both companies now have a roughly equivalent turnover.

The idea of keeping planes in an instable condition was taken from nature. It is a very good example of how a physical phenomenon from nature is investigated, its processes modeled, and then it turns out that purely mechanical control cannot do the same job – in this case for reasons of speed. The process could only be controlled, when a neuron-like communication system was developed – the fly-by-wire system – which was the basis for later developments in the fieldbus area.

The main idea of fly-by-wire systems is communication systems between intelligent nodes, for example between intelligent sensors, actuators, and control units. In comparison to the human body this is exactly the functionality of the peripheral nervous system. However, if we want to copy more than just communication from humans, i.e. their intelligence, we need to work with models of the human psyche, because this is where the major part of information processing takes place. This consideration leads directly to the first problems regarding communication between different scientific cultures or fields. Engineers differentiate clearly between hardware, software, and application. The hardware is the physical part, on which apparently the software runs. Obviously, the software is another description language for certain parts of the hardware. However, two different models are used in order to describe the system. The third model, the application, describes the function – what the thing, the computer actually does for the user. With the help of these models one can describe the whole computer. But what is the psyche in this scenario? The software? The application? We think that this differentiation has not yet been attempted. If we want to model the mind and the functions it performs,

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[6] Surveillance done by humans clearly interferes with privacy, whereas surveillance by machines does not – if the information is not passed to humans again.

and if we additionally want engineers to understand it to enable them to simulate or emulate something, we need to define the terms. Therefore, in our approach the mental apparatus is seen as the equivalent to software whereas the psyche is defined as the application. We will discuss this in more detail later on.

First it needs to be clarified why we are convinced that psychoanalysis offers the answer. In the previous paragraphs it was stated that bionic communication principles can be used for, e.g. fly-by-wire systems. This was even possible without actually copying the whole physical base, the neurons, because electronics provided another base. The same is true for the mental apparatus. One does not need to model the whole human brain with its billions of neurons and interconnections in order to rebuild the processes of storing and processing information. Modeling the human brain neuron by neuron – the bottom-up approach – is not necessary. If one focuses on the mental apparatus, the top-down approach must be adhered to. If these boundary conditions and considerations are adopted and agreed on for the bionic approach then one only needs to turn to those sciences that are essentially engaged in the study of the mental apparatus for the underlying basis for the model. In our view it is a fundamental error to search for and operate in terms referring to specific isolated psychological functions like emotions, feelings, and consciousness, making various assumptions and creating hypotheses about these terms without actually dealing with the corresponding disciplines. The relevant literature has to be seriously considered. This point will be stressed frequently in later chapters, since it is not a scientific approach to simply reject or ignore existing research results, and not to incorporate the state of the art of the respective field into one's own scientific work.

Coming back to the sciences concerned with the psyche. Which one of them could be utilized for the first step of development if the task is to design a unitary model of the mental apparatus following the top-down approach? Neurology is by definition not applicable, because neurologists primarily work with physical, chemical, and physiological processes. A model for higher cognitive functional units is not available. Another science, pedagogy, focuses its interest on learning and education. Psychology on the other hand investigates only very specific aspects of psychological functioning. Such results cannot be used for synthesizing holistic models (a fact that will be expanded on later), mainly because the relevant aspects of control theory – interconnectedness and mutual dependencies through feedback and regulatory circuits – are insufficiently considered. Another candidate, psychiatry, is exclusively concerned with pathological phenomena. Hence, the only science remaining to be considered is psychoanalysis. It has – as the only candidate – an approximation of what engineers would regard to be a unitary model, which gives engineers a very good starting point. If a system is designed from scratch it is not possible to integrate every function in detail. Just think of the first computer developed by Zuse compared to contemporary machines. Every scientific pocket calculator today is capable of performing more functions. Other examples are software tools for architects from the 1980's. Compared to modern ones they were just programs to draw lines.

Simple outline models will have to be used as a basis, which – following a top-down approach – can only represent simple functions. Once this first basic concept is available, its functionality can be refined and enhanced.

But what is the psychoanalytical model – even in its most simple form? It is obviously not exactly what Freud defined. As a natural scientist Freud frequently refined his previous findings and revised his assumptions and hypotheses in cooperation with others. The important set of knowledge for our endeavor is the model available today. However, this immediately poses the first major obstacle. The training of psychoanalysts lasts between 7 and 10 years and focuses on clinical application and not on research[7]. So how can an engineer acquire this knowledge? We engineers will have to accept that this will not be possible.

Every electrical engineer would immediately understand and agree that it would take a psychoanalyst an unbelievably long time to be able to understand and apply Maxwell's equations, which form the foundation of electrical engineering, at a scientific level. Conversely the question arises how any scientist in Artificial Intelligence or Cognitive Science, who grew up in the engineering world, dares to claim that they can understand the psyche in such detail and such depth that they can implement it in a robot. Obviously this is a gross misperception of realities. Understanding this however leaves us with a grave dilemma: How can we engineers acquire the necessary expertise to achieve our ambitious goal of creating the aforementioned unitary model? The only viable way out of this dilemma is – in our view – to incorporate "sources" of such knowledge, namely psychoanalysts, into our project team and work very closely with them. We see no other way.

In this way the problem of communication between cultures, which was mentioned above as a critical issue, can be overcome. If such different cultures collide – as happened between the npsa conference and the INDIN conference in July, 2007 (see (ENF 07) and respective DVDs) – it is very interesting to observe that it takes the partners concerned quite a long time to recognize that they talk at cross purposes. Overcoming this obstacle is essential and will be very beneficial for the envisaged joint model.

Another important phenomenon has to be mentioned: We have to re-question again well-loved terms, which we have become used to as technical terms.

Let us first take up Freud's insights from his effort to describe cognitive processes based on neurological investigation. His failure to do so allowed him to understand – and that has to be seen as an outstanding achievement – that mechanistic thinking would never allow a deeper understanding of an information processing apparatus. Let us recapitulate the fly-by-wire example. The great success of the Airbus was the replacement of traditional mechanical control devices (which combine information and power transmission) with electronic ones. The control system consists of sensors capturing the input signals, a centralized control unit computing and sending the necessary actuator signals and the actuators, that

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[7] Wiener Arbeitskreis für Psychoanalyse; http://www.psychoanalyse.org/

translate the signals into mechanical movement. All components use decentralized power supplies connected via communication systems called fieldbus systems. A similar development is currently taking place in the areas of vehicle technology and railway technology, and one can already predict today that this will have to happen in all areas where automation technology will be used to control the process. This has been a massive trend for the last 15 to 20 years: to strictly separate energy flow and information flow within a system in order to allow a computer system to process the data.

Looking at Darwin's theory of evolution, nature serves as an example for this approach (Dietrich and Sauter 2000). In the amoeba the two flows, energy and information, are connected while in creatures of a higher order like insects or bugs communication and information processing units have already developed: neurons. The reason for this development is easily explained: If information flow and energy flow are combined in the same process, compromises have to be made. Every mechanical transmission in a vehicle is based on such compromises between different requirements, for example the requirement for the car to be moving along a curve or the requirement of driving straight on a highway. Processes can only show some intelligence in terms of flexibility if they incorporate information processing units (e.g. as in the bug).

These considerations lead to the next aspect, why it is not just adequate, but essential to take a deeper look at control systems like the mental apparatus. The answer is that we want automation systems – machines – to solve problems which require far more intelligence than a bug offers. Hence, there are two single possibilities: Either we try to enhance previous findings from natural science research, or we attempt to follow the path of the Airbus and try to find out how nature constructed the mental apparatus. In my personal view the latter strategy is the more promising as it appears to be the shorter and easier way, considering Darwin's hypothesis that in nature the optimal solution to a problem will always succeed. Therefore, it is always promising to look for solutions in the nature surrounding us.

What are the key features that define the mental apparatus? The first insight has already been mentioned: information is processed in a dedicated apparatus. The inputs for that apparatus are the sensors and the outputs are the actuators. But some phenomena even increase complexity: One example would be feedback loops in hormonal systems. Hormonal output is not just activated by actuators and sensed by sensors; hormones also have the potential to change the behavior of the physiology (hardware). However in this first approach it is not possible to elaborate on this particular aspect in more detail.

The second important insight was to understand how humans recognize images and scenarios (see Section II.2). We do not perceive our surroundings like a camera, pixel by pixel. Rather, human perception and recognition turns out to be a highly complex sequence of processes. The first step is to depict characteristic parameters like lines and curves. These characteristic features are then associated with images which have been stored previously in our "big" database – our memory. All this data is then processed to what we consciously and unconsciously see, smell, taste. Following this picture, the mental apparatus is just an enormous database that mainly processes images and scenarios. This model of perception and recognition provides us with a theoretical basis for a description of the functionality of the psychic apparatus which in due course can be used for modeling.

The third insight, which Freud also arrived at early on, is: the psyche consists of dynamic processes of inhibition and excitation. The ideal world of stable tranquil harmony is a product of wishful thinking and does simply not exist in the real world. Inside the mental apparatus antagonistic forces collide continually and have to be constantly counterbalanced by the mental apparatus. This means that the process or processes of the mental apparatus are constantly in danger of slipping, getting out of balance.

Let us go back to the example of the Airbus 320. It has a physical stability problem: as long as the plane is in a stable position, it needs more fuel. Therefore, it flies in an unstable position and has to be kept in balance between climbing and sinking at a frequency of 10 Hz. It seems that nature has found large advantages in the instability of dynamic processes. This is the direction we need to direct our investigations. The only thing we can say at this point is that there must be reasons why such systems prevail. Let us adopt the principle and analyze it.

All abovementioned considerations lead in one direction: How can an engineer utilize the findings of psychoanalysis? It has been mentioned only once that the mutual communication between both disciplines has advantageous consequences for both. Being engineers, we can only talk about a few psychoanalytical expectations, because we cannot speak for psychoanalysts here. However, we can decide together what is possible and what is not. Though there is one thing we have learned in these last nine years of hard, collective research work: the way that psychoanalysts think will sometimes differ to our opinion as engineers, especially where developing a model is concerned. Our strength as engineers is developing systems. That is what we have to offer.

## 2 Basics

In this chapter we wish to build a common understanding of the scientific disciplines of engineering and psychoanalysis. Since they not only differ in vocabulary, but also in methodology and way of working it is not easy to build this bridge, and it will require at least two textbooks to do so. However, as this is not feasible, we have included short introductions to the main scientific fields, followed by discussions about their position in science and the relations between them.

### 2.1 Introduction to Automation

The introduction of the term automation has been awarded to the Ford manager D. S. Harder in 1936. Originally, it defined the automatic transport of a mechanical object from some point A to point B. Later the term comprised a complete manufacturing process. Nowadays automation refers principally to any kind of feed-forward or feedback control of processes.

While early automation was only concerned with purely mechanical processes, it was realized quickly that electrical engineering had the potential to not only transfer control impulses, but also to generate information from diverse sensory sources. In this way it was possible to design devices capable of starting engines or operating valves dependent on particular measurable conditions like temperature or pressure. Due to these historical roots, the whole idea of automation was originally based on a mechanistic way of thinking. The first transformation in this respect started with the presentation of the first programmable computers: the *Z3* in 1941 by Zuse in Germany and the *Mark 1* in 1944 by Aiken in the US. This development led to fundamental reconsiderations in automation: The new devices offered the possibility to work with information about the observed process, separated from the process itself. In other words: to replace the built-in mechanical control systems by much more flexible and precise electronic automation systems which operated remotely from the work process proper.

To summarize, the development of automation up to its current level may be subdivided into four steps: The very first automated processes were highly sophisticated mechanical processes (like wind mills, steam engines, or mechanical watches). In the next step, electrical communication was used to transfer the information about events in automated systems. In a following step, more information about the process was collected via sensors and translated into electric signals. These signals were then used for computation in fixed electronic circuits in order to better control the process. The fourth step to modern automation was the introduction of computer systems instead of the electronic circuits, which allowed process control using free and flexible computation[8]. The whole automation system thus consists of the following components:

a) Sensors to observe various physical parameters of the process and translate them into electrical signals.
b) The control unit, which is usually a computer, collects data, stores it and computes signals for the actuators. Those signals are based on target-performance comparisons between collected data and a programmed abstract model of the process, and
c) The actuators that translate the computed output signals of the control unit back into physical actions – which consecutively affect the process such that it attains its desired physical condition.

This structure is typical for a so-called fieldbus system, which will be referred to later.

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[8] One example to illustrate these developments is light: The first lights after torches were gas lamps (totally mechanical), later replaced by electric lamps controlled by switches (simple electrical communication). The next generation including electronic control was light controlled by a dimmer switch. Finally, modern illumination systems are controlled by fieldbus communication systems.

This functional distinction between the four areas: sensors, controllers, actuators, and communication systems led to the current sub specializations in automation.

There is sensor development on the one side – which is basically a physical or mechanical topic. It has specialized towards micro technology or, later, nanotechnology. Recent research results from this field predict a considerable increase in low-priced, but highly capable sensors.

The second field, communication technology, was accepted in automation since the late 80ies with the rise of fieldbusses. A fieldbus is defined as a communication system connecting sensors, actuators, and controllers in order to exchange data. Fieldbusses are bidirectional, which means each device can send and receive information as required. Sensors and actuators received their own control and communication modules to make them "intelligent" (or "smart"). Without this additional feature it was just possible to read a sensor's value or to send a control signal to an actuator. Bidirectional communication e.g. allows the control unit to (re)parameterize sensors (program them with new parameters like exposure time for cameras) or actuators, if necessary, to communicate their range of abilities to the control unit during operation.

With the capabilities of the various devices enhanced in such a way, the separation between sensor, actuator, and control unit becomes less and less important, since devices originating from the three fields of specialization can nowadays perform almost all functions involved in the entire automation system. Therefore, today the function type is distinguished, not the device type, since a smart sensor possesses fully integrated controllers and communication systems.

The third focus in automation is the discipline concerned with the unit between sensors and actuators – the controller, or control unit. A controller processes the essence of the automation system: the information about the process. This research field is divided into several parts, mainly dependent on the area of application. Two of them are of greater concern for us, namely computer engineering and electrical engineering. Computer engineering is only concerned with software. Automation in computer engineering deals with mathematical descriptions and algorithms of and for processes creating abstract models of the real process implemented in software. Electrical engineering additionally deals with the computer hardware. Special purpose chips and devices – embedded systems[9] – are an emerging topic. They are specifically designed for each automation system in order to provide the respective controllers with exactly the functionality they need for their specific performance. In recent times the interconnection of such devices has become increasingly important again.

The forth area is the area of propulsion technology. In earlier times this was an application-dependent, highly specialized field, because e.g. very different technologies are involved in building a motor, depending on the power that the motor

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[9] The first step in automation towards computer controllers was to use so-called PLCs (Programmable Logic Controller), central processing units.

must provide. Nowadays, the separation between sensor, propulsion, communication, and control technology softens, because computer technology unites the technologies and allows systems to be designed that integrate all of the above technologies in one device.

Nowadays, fieldbus and related technologies can be seen in virtually all areas of technology, starting from air and space technology (where it originated) to industrial automation, building automation, and forest or railroad technologies.

Hot topics in current automation research are the following:

- Some applications demand reaction times within specific time constraints, so that the process can be kept on track – so-called *real-time systems*. How fast this reaction is in terms of time units, depends on the application: it can be minutes for controlling the temperature in a room, or small fractions of a second for controlling the braking system of a car.
- Another new direction of research is targeted at *decentralized systems*, where the computational power and the intelligence is distributed over a network. This is in contrast to traditional centralized systems where a dedicated (controller) unit is responsible for all computations and control.
- The latest areas of interest are: embedded systems, ad-hoc sensor networks, and smart dust. These terms refer to various stages of development of basically the same idea – having large numbers of small, wirelessly interconnected sensing devices embedded into physical objects. These networks of sensors are supposed to measure any desired physical condition in any desired location.

  The vision of an *embedded system* is to integrate the whole electronic part into one single chip or small device.

  The specific criterion of *ad-hoc sensor networks* is that not all units within the network are directly connected. Direct communication depends on the distance between devices.

  *Smart dust*, today being merely a utopia, is the term for having one single unit containing sensor, controller and communication, that is so small that it virtually requires no energy source and can be placed within wallpaper.
- The area of safety deals with ensuring reliability and availability. The problem with electronic devices is they may fail from the very beginning on (in contrast to mechanical devices). This probability for failure remains approximately constant over their lifetime (while mechanical systems fail with higher probability as they get older due to frictional loss and material fatigue).
- The next direction targets the costs of the entire life-cycle of electronic devices considering design, fabrication, and maintenance. This is particularly important in Europe, since personnel costs here are decidedly high, and natural resources are only available in a few countries like Norway or Great Britain. It is therefore no wonder that in the area of automation Germany and France lead the world market, both, in industrial and building automation.

Finally, a general trend in automation needs to be highlighted in particular, being the paradigm shift away from mechanistic thinking. As mentioned in the first chapter, Freud claimed 100 years ago, that, in order to understand the mental apparatus, mechanistic ways of thinking have to be relinquished. The same is true for automation. In the current situation we engineers learn (and teach) modeling physical processes via abstraction. We learn to linearize (to describe complicated correlations with simplified, linear correlations), to minimize the number of observed parameters, to ignore side effects, and to split complex processes into sub processes and thus to create models with strongly reduced complexity. In addition to the obvious reasons, to promote easier understanding and handling of correlations, another practical reason is that today's sensors are expensive to purchase, install, and maintain as well as often being of low quality. Hence, the process cannot be observed in too much detail. We can therefore afford to have not very differentiated models.

However, our goal in process control must be the opposite! The whole process should be observed in full detail including all influences coming from outside the process ("disturbances"). And if it is necessary to split the model of the process into smaller functional units, the mutual interferences of those functional units must be described ("interfaces").

Such requirements imply mathematical and computational challenges. The incorporation of all – presumably non-linear – influences will not allow for simple solutions. However, taking ever-increasing computational resources into account, it is no longer necessary to limit the model's description to simple mathematical specifications. Complex problems can be simulated in split seconds on standard desktop PCs. Even the computational power of most embedded systems is sufficient to handle such problems. Additionally, if units with less capacity are involved in distributed systems, they can outsource computational tasks to more potent units in the network.

The level of available resources today is favorable; only one thing needs to be considered: There must be enough sensors to observe the process. By using a large number of sensors automation systems imitate a rule of nature. Creatures at a higher level of development tend to have more sensors to perceive their environment with. So if we want automation to improve its abilities, we need to provide a sufficient amount and variety of sensors.

As stated above, a sensor translates a physical property into an electric unit. Modern (smart) sensors do not send analog values, but digitize them and send them via a communication system (e.g. fieldbus) to the controller. Aside from the great advantages of flexible computation, digitizing information close to the process allows the replacement of electronic circuit elements. This is desirable because electronic circuit elements always obstruct complicated, higher-order circuits due to their inaccuracy. Additionally, due to their size they are influenced by electro-magnetic waves. All these side effects can be avoided by processing the data in a computer.

In the areas of digital technology, the principles mentioned are already state-of-the-art. Two impressive examples are software-radios and vehicles. A software-radio is a device that digitizes radio waves – which a normal radio also receives – i.e. it turns the radio waves into digital data. All processing, filtering, amplifying, etc. is done digitally. Non-linearity or inaccuracy of components no longer constitutes implementation problems. All circuit related electrical engineering problems are easily solved in the computer. Finally, only the computer-generated signal for the speaker is converted back to an analog signal. The only significant effort remaining is the mathematical description of the process itself.

Secondly, the current trend with vehicles is to replace mechanical and especially moving parts by electronics. In particular that means the engines in future will be directly integrated into the wheels in order to eliminate the steering wheel and the brakes. Friction will be dramatically reduced, while completely new ways will open up for the design of the passenger compartment in a car. Such cars will have to have a large number of integrated sensors.

To summarize, the future trends in automation are: Processes will be observed by an increasing number of sensors. Sensors as well as actuators will become more intelligent. All units in automation systems will become interconnected and transfer their knowledge to control units which perform the necessary mathematical computations. These control units will either be organized centrally or distributed over networks. Finally, we claim that these computations will also incorporate principles of the human mental apparatus – the highest developed control unit known in nature. In this respect, Darwin will again be proven right.

## 2.2 Introduction to Psychoanalysis

Psychoanalysis is a discipline which incorporates subjectivity into natural science. Sigmund Freud (1856-1939), its founder, was the first to conceive and formulate it. Based on Freud's books and lectures, psychoanalysis has since developed into an intellectual movement with a lasting influence on Western culture. Psychoanalysis significantly determines the present concept of psychotherapy and in a wider sense our idea of the human condition as a whole. It has opened up new perspectives for neuroscience, psychiatry and psychology and is a source of inspiration for many fields in the humanities and for a great variety of arts. Against the background of an understanding of unconscious processes, the assessment of civilizing, societal, cultural and artistic processes has been substantially changed and enhanced. The description of psychoanalytic theory below is closely associated with Sigmund Freud as a person. This should not be misunderstood as an effort to place the person of the founding father of psychoanalysis centre stage; in the first decades of psychoanalytic theory, however, its development was strongly linked to Sigmund Freud's research, his development and later of course also his rejection of his theories.

What remains central, however, is that psychoanalysis represents a theory of the development and functioning of mental processes based on clinical observations made in a specific relationship situation which can be described as the psychoanalytical setting.

Freud describes psychoanalysis as follows: *"Psycho-analysis is the name (1) of a procedure for the investigation of mental processes which are almost inaccessible in any other way, (2) of a method (based upon that investigation) for the treatment of neurotic disorders and (3) of a collection of psychological information obtained along those lines, which is gradually being accumulated into a new scientific discipline"* (Freud 1923a, p. 235). He goes on to differentiate: *"The assumption that there are unconscious mental processes, the recognition of the theory of resistance and repression, the appreciation of the importance of sexuality and the Oedipus complex – these constitute the principal subject-matter of psycho-analysis and the foundations of its theory"* (Freud 1923a, p. 250).

Accordingly, psychoanalysis is:

- A psychological theory of the mental life and experience, particularly of their unconscious parts;
- A procedure for the investigation of unconscious mental processes;
- A method for the treatment of mental disorders;
- It is a process to understand the unconscious psychic reality of a person and its method is primarily that of observation and interpretation.

Since its conception more than 100 years ago, psychoanalysis has developed further and gone in different directions resulting in different methods of psychoanalytic work and thinking. Freud's writings, however, continue to be the basic introduction to psychoanalysis and reading his texts remains indispensable for any in-depth study of this particular science.

Born in 1856, Freud came from an already widely assimilated and liberal Jewish family. In the Freud biography his markedly enlightened and rationalist attitude is related among other factors to this background.

The main publications written in the initial years of his work concentrate on neurological topics – for instance his essays on aphasia (Freud 1891) and on infantile cerebral palsy (1897a). In his essays on aphasia, Freud argued decidedly against a general localization of brain functions and thus explaining, among other things, brain activity. Additionally he describes that language would not be possible without consciousness; for the engineering sciences this must mean that a machine will never be able to understand human language if it does not possess a technical equivalent of consciousness. A first publication on hypnotic suggestive therapy (Freud 1892-93a) was followed by others on psychological-psychotherapeutic topics, notably "The Neuro-Psychoses of Defense" (Freud 1894a) and "Studies on Hysteria" (Freud 1895d) co-written with Josef Breuer. The "repression theory" set forth in these writings which explores the mechanism of neuroses is later replaced by the "theory of seduction" with the aim of defining the cause of neuroses. This theory is developed further in "Further Remarks on the Neuro-Psychoses of Defense" and in "The Etiology of Hysteria" published in 1896.

In 1900 Freud published "The Interpretation of Dreams", which is considered to be his most important work; it is based on his insights from his self-analysis that started in 1897. The assumptions necessary to explain the events taking place in our dreams, i.e. the existence of two mental agencies, the system "conscious-preconscious" on the one hand and the system "unconscious" on the other with a "censor" localized in between, introduce the fundamentals of "metapsychology" and include the basic psychoanalytical assumptions about mental processes.

In "Three Essays on the Theory of Sexuality" (Freud 1905d) Freud undertakes to substantially expand the general understanding of sexuality. In the time span of only a few years he proceeds from abandoning the theory of seduction in 1897, thus bringing the "prehistory" of psychoanalysis to an end, to the development of its essential contents – the theory of the unconscious, of infantile sexuality and the conception of neuroses being based on unresolved conflicts from childhood.

Later publications include Freud's writings on the general psychological and biological fundamentals of psychoanalysis (theories of the unconscious, the drives and sexuality) clinical papers (case studies, essays on the general theory of neurosis and psychotherapy) as well as texts on the application of psychoanalytic findings to non-clinical contexts and certain phenomena (parapraxis, jokes, literature, religion, culture and society).

According to the above assertion that apart from being a method for investigation and a psychological theory, psychoanalysis also represents a method for conflict resolution, Freud's writings also provide meta-psychological observations as well as reflections on technical and methodological issues in treatment. With regard to the latter he develops concepts important for psychotherapy such as "free association", "poised attention", "resistance", "transference", "abstinence", "importance of the setting" and others.

Attacks on psychoanalysis are part of the history of psychoanalysis. From its inception in turn-of-the-century Vienna, psychoanalysis has inspired strong feelings. Early reviews of Freud's account of his novel treatment of hysteria emphasized the humanity of the talking cure, the methods it offered for exploring the inner world of human emotional life. At the same time, the negative reviews were hostile to the point of dismissal, attacking the subjective, "unverifiable" nature of the analyst's report as well as ridiculing the emphasis that Freud placed on the sexual origins of mental distress.

The famous splits in psychoanalysis in the years 1911-13 are associated with the names of Sigmund Freud, Alfred Adler and Carl Gustav Jung. Freud and Adler were divided about the fundamental question of human action: are we masters of our fate or do we act out of instinctual conflicts of which we are largely unaware? Adler, inspired by his personal and clinical experience, felt certain that human beings do create their own world. In his view, we do things not *because of* but *in order to*. Freud could not accept Adler's view of the centrality of human agency in light of his experience of the unconscious motivation in human affairs (Handlbauer 1990).

The fundamental disagreement between Freud and Jung was the conflict between modern Western science and traditional Western spirituality (Freud 1974). Jung took a classic position in opposition to the materialism of Western science by insisting that nothing could exist unless it was perceived. Jung created a psychology by evocation of symbol and myth and the intriguing question of the collective unconscious. It is the idea of a collective psychology, operating at a very deep level in the human psyche (Jung 1976).

A paradigm shift of psychoanalysis began to emerge in the 1920s with the psychoanalysis of children associated with Melanie Klein's work. The fundamental theoretical problem posed by child analysis was to understand the origin of childhood anxieties. Klein pioneered the technique of play analysis – the use of a set of small toys as a substitute for the technique of free association. Through observation of the play, the depths of a child's inner world could be reached by making immediate interpretations about the child's earliest feelings and unconscious fantasies, many of which have made an important contribution to our understanding of early separation anxiety. Within the framework of the existing metapsychology, Klein added on and redefined highly relevant aspects of the early development of the psyche and to the technical repertoire of psychoanalysis (Klein 1935, 1946).

Now psychoanalysis is still widening its scope. With the most recent advances of the neuropsychoanalytic method psychoanalysis once more is enlarging its scientific possibilities. There is an approximation between psychoanalysis and neuroscience, where neuroscience could provide a more concrete empirical and conceptual basis for correlations with psychoanalytical concepts. Since the 1990s, Mark Solms, president of the International Neuropsychoanalysis Society (npsa has worked on presenting a new method of research in neuroscience (Kaplan-Solms & Solms 2000) adapting the traditional neuropsychological method developed by (Luria 1973) for the study of cognitive functions extended to emotional phenomena, which psychoanalysis has been investigating for over a century.

Essential for the topic of this book, however, is Freud's metapsychology as it forms the psychoanalytic frame of reference of the ARS-PA model described later on.

In 1915 Freud defines the concept of a "metapsychology" more specifically as a system informing about the localizations of mental processes in the postulated parts of the psychic apparatus (topography), the forces responsible for their occurrence (dynamics) and the amounts of energy (economics) thus relocated: "I propose that when we have succeeded in describing a psychical process in its dynamic, topographical and economic aspects, we should speak of it as a meta-psychological presentation" (Freud 1915e, p. 181).

As the essential characteristics of topography, dynamics and economics are the defining factors of Freud's metapsychological theory and as they are repeatedly applied to different topics, these three perspectives shall be summarized here:

The topographical perspective: *"The crucial determinants of behavior are unconscious"* (Rapaport 1960, p. 46).

Psychoanalysis names and conceptualizes what is not perceived or not perceivable and does so exclusively in psychological concepts such as motivation, affects or thoughts. Therefore Freud developed the topographical models with their locations of unconscious, preconscious and conscious contents (Freud 1915e), as well