Natural Scientific, Psychoanalytical Model of the Psyche

for Simulation and Emulation

Scientific Report III

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In order to achieve a style and phrasing as homogeneous as possible despite the many contributors to the scientific report presented herein, the English version III was translated by *Stephan Stockinger*[1] and subsequently revised, modified and extended to include our most recent findings.

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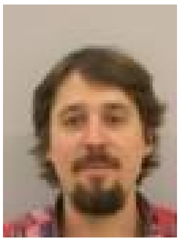

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Abstract

Artificial intelligence delivers excellent results – for example in search functions on the internet, in the high performance achieved by modern robots, and in EU projects like SENSE [Bru 12], which provided exemplary implementations for the security of Krakow Airport in Poland. Nevertheless, there still exists no robot capable of preparing and serving a cup of coffee, and no kitchen monitoring system that can recognize a potentially dangerous situation for a child. We must not only ask ourselves – and thus evaluate – why such goals have not yet been reached around 60 years after the establishment of artificial intelligence, but we must produce new suggestions as to how they can be achieved using the knowledge we have today: High cognitive, human-like capabilities for machines allowing the execution of complex processes.

This report elucidates pivotal problems in cognitive research and presents an approach to a solution that shows great promise from the perspective of modern information and computer engineering. It is an approach that breaks completely new ground in artificial intelligence, with researchers no longer concentrating on individual neurological or mental phenomena, but instead developing, for the first time worldwide, a holistic model of the brain.[2] The project neither intends to, nor could it ever lay claim to incorporating all phenomena of the brain or all of its capabilities, however; the term “holistic” in this sense means that our model of the brain is being developed on the basis of the psychoanalytical model concepts. This occurs primarily on the basis of the theoretical computer science concept of the layered model under incorporation of the hardware layer (thus differing markedly from many layered models in informatics). A further pillar of the development of the presented model is the method of Top-Down-Design used in natural science, wherein “Top” refers to the psyche with its unconscious, pre-conscious and conscious information in the primary and secondary processes. Beneath it lies the layer of neuro-symbolism, and beneath this is the description of the “hardware”, i.e. the model of the purely physically described part of the system. This also means, however, that it will be possible in future to implement the model, described through functions, in robots or appropriate software agents; this step is scheduled to begin in 2016/17. The result that can be presented today is a highly extensive simulation program evaluated via use-cases, which are currently still simple but will be increasingly more intricate, thereby also allowing the progress of the entire research project to be gauged.

Work on the project has been proceeding at the Institute of Computer Technology at the Vienna University of Technology for the past 15 years under the direction of Prof. Dr. Dietmar Dietrich, in cooperation with various institutes around the world (South Africa, Canada, Spain, Portugal, Germany, etc.). Today, the project leader is Samer Schaat.

[2] Axiomatically speaking, the term “brain” is somewhat problematic. The defined goal of simulating the “brain” is in fact not really achievable without including the entire nervous system. A correct scientific terminology must therefore speak of the nervous system in which the brain is included as a part.

Preface

Classical Artificial Intelligence versus Human Thinking

Dietmar Dietrich

Previous attempts to create artificial intelligence have led to results which are not truly commensurate to the capability of human thinking. For this reason, a radically different path is taken in the SiMA project by attempting to develop in an engineering fashion a model from psychoanalysis which describes the structure of the human psychic apparatus. The consolidation of psychoanalysis and computer engineering results in the collision of two very different ways of thinking, but at the same time the two fields possess surprising commonalities which were hitherto unrecognized. These commonalities can only be understood if viewed from the perspective of natural science. The results up to this point are convincing, as for the first time in history a holistic model of the information system of the brain has been comprehensively developed using methods of natural science. Comprehensive should be taken to mean that the functions of the nervous system, beginning with the sensor as a bioelectric unit and reaching all the way to the functionality of the consciousness have been described to a degree that allows them to be simulated and also emulated technically, i.e. their function can be artificially reproduced. Hence for the first time, human intelligence – human thinking – becomes technically reconstructible. Comprehensive does not mean that the brain can be simulated in all its details. We are still at the beginning, but as engineers and natural scientists we are aware that we are turning over a new leaf.

The SiMA project (Simulation of the Mental Apparatus & Applications) was initiated in 1999 by Dietmar Dietrich in order to understand how the brain as a whole works from the point of view of information theory, with the knowledge of psychoanalysis to be extensively incorporated. The goal was to model and simulate human thinking by methods of natural science and engineering via the scientific findings of psychoanalysis, and to eventually integrate the result into devices which require such intelligence (e.g. decision units for surveillance systems, robots, risk assessors, etc.).

Algorithms Until now – put in simple terms – most approaches have tried to describe logical information processes purely mathematically and program them accordingly. Algorithms were constructed based on queries: If parameter A is greater than value B, then strategy A is applied; otherwise, strategy B is applied. There exist evolutionary algorithms which belong to the group of stochastic, metaheuristic optimization procedures. There is machine learning, where artificial knowledge is generated from processes to be able to deduce certain principles after a learning phase. The basic notion in all of these approaches is that the processes are exclusively dependent on mathematically describable algorithms, and this is also why artificial intelligence has mostly found a home in mathematics and informatics. A strange and unsolvable problem persists, however, in that high intelligence – in whatever definition – in an individual exists only in humans, which in turn cannot exist without feelings. If one therefore describes logic exclusively with the help of mathematical algorithms that disregard feelings, then only a certain spectrum of intelligence will be encompassed, but never all of it. Hence mathematics is not sufficient for the description and development of intelligent systems if they are to approximate human performance.

Robots In parallel to artificial intelligence, the research field of robotics was developed. This field is likewise oriented around the human exemplar and is likewise currently reaching its limits in trying to simulate the human decision unit, i.e. the psyche. Replicating the shape of the human body has nothing to do with intelligent human decision-making and the associated decision unit of man. One projects human feelings into such machines, but their insides are still high-powered and yet conventional computers functioning as we know them – electronic automatons. And although the exteriors of robots continue to become ever more realistic and their behavior is improved in small steps every now and then, they remain machines whose form and behavior is similar to that of humans, and nothing more. There is still no robot that can serve a cup of tea in the morning; although such capabilities have been promised repeatedly for decades, we are still far from them being a reality. To this day it is a real challenge for a robot to tell a table from a chair. To put it bluntly, robotics has hitherto focused on emulating human appearance and sometimes behavior, and so the robot scientists have focused their interest on physical laws and not on information theories. Their results have nothing to do with "humanness", however; in order to understand the nature of the human decision unit – how it works –, we must investigate its functionality, i.e. how human behavior is created using the brain functions.

Computers In contrast to informatics, computer engineering has to deal intensively with hardware *and* software. The phenomenon of electrical energy, and information processing in general therefore play important roles. The computer technician learns to work with electronic sensors as well as with data processing. It was computer technicians who developed the first machine (before the establishment of informatics) capable – like humans – of processing large quantities of data: the computer. Computer technicians learn the difference between hardware and software and know that the two concepts are merely different methods of accomplishing the same thing. From the perspective of information theory it is important to know that this also means computer technicians must understand the interface, the transition, between hardware and software. It is equally important to be aware that if a computer technician wishes to develop computers to control processes, he must analyze the behavior of those processes to derive computer functions that will eventually control the process. This is the central topic of computer engineering: How does one derive the controlling functions of the machine from the desired process behavior?

Psychoanalysis Psychology researches and describes phenomena of human behavior, experiencing and intelligence. Psychoanalysis, a branch of psychology, is the only science to have hitherto developed – in its theories of so-called metapsychology – a model that describes the human psyche, i.e. the mental apparatus, in its entirety. It does not content itself with the description of individual behavioral phenomena, but attempts to explain all these phenomena through a *single* functional model. Sigmund Freud as the founder of psychoanalysis attached great importance to the application of natural scientific thinking and appropriate methodology. I see his genius primarily in the fact that he recognized – more than 100 years ago – that the thought process and thus the psychic apparatus itself cannot be reduced to the description of local neuronal centers, as has been attempted again and again. Instead, a strict differentiation must be made between *functional units* and *behavior*. Freud was not interested in statistical connections with regard to human behavior, but rather in the *functions* of the psychic apparatus and their interdependency. Hence he developed the second topographical model with its central *functional units* (often called *entities* in computer language) called the id, ego and super-ego - and this represents precisely the way of thinking of computer technicians as developed only around 60 years ago in computer engineering which *functions* control the process, and how? Freud's first topographical model, in which he differentiates between conscious, pre-conscious and unconscious information/data[3], can be used as a data model by modern-day computer technicians, and on the basis of our modern knowledge harmonizes well with the second topographical model. Due to the immense significance of this fact, it must once more be emphasized that the second topographical model involves a functional way of thinking which was "reinvented" for the field of technology by computer science several decades after Freud in order to be able to understand and develop the machines of information technology: computers. This to me proves the ingenuity of Sigmund Freud.

Interoperability When the SiMA project (previously bearing different names) was first launched, we were aware that reproducing the theories of psychoanalysis in a purely natural science-based model that could hold up to the theories of computer engineering without contradiction would be a massive problem. However, the true scope of difficulty has only become apparent over the past few years. The foundation on which computer technology rests consists not only of mathematics, constantly developing information theory, the mastery of appropriate technologies and knowledge of physics, but also includes knowledge about the interoperability (functioning intercommunication of processes) of these systems. This implies a clear standardization of terminology deduced from the field of mathematics. We computer technicians depend on precise axiomatics and standards. The topic of interfaces is the best example of this fact: Huge amounts of money are invested worldwide for the definition of interfaces in technology. Such sums are obviously not available for the field of psychoanalysis, and therefore interoperability must be a central topic within the SiMA project if the goal of realizing a technical model of the psychic apparatus is to be achieved.

[3] Data are the carriers of information. Such definitions are the basis for an axiomatic approach and are examined in detail in the SiMA project.

SiMA What, then, distinguishes the structure of SiMA from the algorithms of artificial intelligence? What are the unique characteristics of SiMA?

In SiMA, the brain is perceived as an information system which stores, manipulates and transfers information/data. In order to describe this system, it is viewed – as is common in computer engineering – as a layered model which includes the hardware layer (as per the concept of the Mealy Machine). We have defined three functional layers: The layer of the neurons, i.e. the bottommost layer 1, can be described as the hardware, and the processes therein can be described with the corresponding laws of physics and (electronic) logic. The next higher layer is called the neurosymbolic layer. It is to be understood exclusively as a functional layer which cannot be described in terms of physical laws, meaning that hardware-based descriptions are no longer useful since the complexity does not allow them to be determined efficiently. In this layer, pieces of information are brought together and differentiated into their micro-units in the inverse direction of data flow. That this layer is hitherto unexplored in humans poses no problem for the computer technician as long as interoperable interfaces to the underlying layer 1 and the overlying layer 3 can be described. “No problem” should be taken to mean that appropriate mathematical models for layer 2 can be developed from these interfaces, as has already been proven within the SiMA project. The topmost layer 3 is separated into the lower primary process in which data/information is handled and manipulated unconsciously, and the secondary process above it in which various data/information pieces can become conscious.

In all three layers, various mechanisms valuate and modify, i.e. manipulate, the information/data. For example, when currents flow from the cone cells in the eyes to the brain via nerves, the data modelled therein are constantly assessed and changed during their passage through the different layers before actually becoming conscious in the secondary process. In the primary and secondary process alone, SiMA differentiates between five valuation quotas (the quota of affect, the basic emotion, the expanded emotion, the neutralized psychic intensity and finally the feeling) which to some extent merge into each other and are also partially interrelated via the neutralized psychic intensity. Psychoanalysis uses the term “psychic energy” for the intensity of psychic phenomena. Based on these models, decision-making in humans occurs not via pure logic, but is instead negotiated in valuation spaces (based on the question of whether something feels good, less good or even bad). Damasio and Solms say that humans make decisions not solely intellectually, but that feelings are incorporated into decisions as well. In terms of the SiMA project, we can say that logic is superimposed on feelings.

In summary, the distinguishing characteristics of SiMA can be identified as follows:

(a) the layered model with three layers separated into different levels according to the top-down principle and
(b) a fivefold valuation system for the information/data.

Functional Layered Design The question often arises: Why did this complicate functional layered structure develop in the brain?

Before attempting an answer, it should be mentioned that the question itself is unfortunately phrased, for the term *functional layered structure* is an artificial term for a model just like the term *black hole* in astronomy – it is an attempt to find a model for reality in order to understand that reality with our human mind. One would therefore search in vain for these *layers* in reality; they are explanations similar to the terms *hardware* and *software*. Such aids for understanding are often used in information theory, for example in regard to the aforementioned Mealy Machine (finite-state machine) used to calculate electronic circuits. For the Mealy Machine, logic is split off from the hardware, which in physical terms really makes no sense – but it allows mathematics to be applied to this particular reality and we are thus able to calculate the circuit. To this day no alternative to this method is available[4].

Thus the abovementioned question can be answered only if one adopts the methods of description innate to information theory (of computer engineering).

The evolutionary history of development of animals and humans provides information on how the nervous system – that is, the nervous information system – has developed through the animal kingdom all the way up to humans. The first and second layers of the brain can be relatively easily explained with the information theory of computer engineering, for the currents from the sensors must be converted into symbols, images and motions(the data objects of the interfaces between layers 2 and 3), and this conversion represents an abstraction of reality. This process can only occur via a hardware layer and a neurosymbolic layer. But why must the third layer be separated into a primary process and a secondary process? The history of development provides an explanation once again: The first neuronal networks developed in animals like ants, flies and fishes in which – adhering to the terminology of computer technicians – only the first layer, i.e. an “electronic” network in which certain inputs generate corresponding outputs, was formed. Later, more highly developed animals began to abstract – meaning they became able to summarize information/data, thus forming the second layer, the neurosymbolic functional layer. These creatures can react more intelligently in nature, for they are capable of analyzing and correlating information/data more quickly and simply on a higher, abstract level. The next higher developmental level was the formation of the primary process, the lower level of layer 3. This includes the abstract integration of bodily needs of the id in the form of drive representatives and repressed contents as well as abstract, symbolized perception via symbols, images and motions from the outside. The abstractly perceived objects of the physical world, i.e. the outside world as Freud called the physical world including the own body, are stored and correlated with the currently perceived objects. All symbols, images and motions(of objects), that is, everything that is stored, is always stored in a valuated form – valuated using the abovementioned fivefold valuation mechanism. A thing presentation network is created which forms the basis for associations in the primary

[4] Dietmar Dietrich (one of the authors of this scientific treatise) perceives this as the reason for psychoanalysts and neurologists hitherto being unable to find a reasonable way of consolidating the psychoanalytical and neurological models, while SiMA has proven capable of bridging this gap.

process. Incoming perceptions are linked up with valuated memories, thus resulting in a constantly changing internal situation.

But the most highly developed animals and humans can do even more than this. They are capable of (long-term) planning and of setting aside current needs in favor of their planned goals. They are able to construct highly complex social rules which they develop logically, by thinking. This constitutes the secondary process. To prevent these thoughts from continually falling into conscious conflict with the ever-urging wishes of the primary process, there exists an immense fortress of defense mechanisms in the primary process intended to enable the intelligent creature to view the world in simple patterns learned early on, thus disengaging itself from the tangle of contradictions. On the basis of internalized rules, the defense mechanisms prevent the majority of information from becoming conscious; they can invert information/data into its opposite, overvaluate certain needs to suppress others, etc. All this makes man what he is. In the secondary process, humans ultimately decide – based on the information/data allowed by the defense mechanisms – what they consider to be right or wrong, and what they need to do. This means that the entire decision-making process is based on subjective information processing of a huge individual body of knowledge and many conflicting incoming and stored pieces of information/data. The structure of the human brain is therefore much more *complex* and contradiction-laden than any hitherto developed decision unit of artificial intelligence.

Difficulty Why do we have no finished, utilizable results to show although we have been working on the SiMA project since 1999? Over time, I have formed an opinion on this topic which may appear somewhat harsh, but in truth mirrors our current level of knowledge.

To be able to work on this project, one must be open to both involved disciplines: psychoanalysis and computer engineering. Open means that one must deal with both fields in regard to contents. Unfortunately, psychoanalysis is increasingly being researched by persons who have little knowledge of natural science. They do not understand – from the perspective of natural science – the difference between Freud's *functional model* and the *object relations model* which represents a *data model* for computer engineering. They barely understand that the *functional model* represents the basis for the *object relations model*. They do not recognize at all that precisely this constitutes Freud's genius. Both the *functional model* and the *data model* (*object relations model*) are required, as computer engineering shows us. But psychoanalysts have no interest in integrating the knowledge of computer engineering, and computer technicians similarly regard the not immediately provable findings of psychoanalysis as improper models in terms of natural science. They do not see the holistic mathematical description of these models (which of course is the ultimate engineering goal). Thus two worlds of ignorance collide in the worst possible way, resulting in few research proposals being funded, very few enthusiasts actually keeping at the project, and presentations being met with often emotional or completely injudicious reactions of anger and anxiety.

Vision Once technology has largely understood the processes in the brain and is capable of describing it like other organic processes in humans, automation will be able to achieve far more than it can today. Machines are currently still incapable of many things, like monitoring an airport, even though vast amounts of money have been invested into corresponding research. They are unable to interpret courses of action, recognize social correlations etc. To this day these things are the domain of humans because they are able to access their own valuated experiences in a particular way. It is the goal of the SiMA research to achieve this insight. This will naturally be a never-ending story, but we believe to have turned the page toward a paradigm shift in automation that will open new perspectives. For the first time ever, machines will have feelings the way they are defined in humans – though of course these will be machine-feelings (never human feelings), since machines are built from a different material and, in particular, do not reproduce.

Abbreviations

AI	Artificial intelligence
ARS	Artificial Recognition System
CS	Cognitive science
DM	Drive mesh
MRI	Magnetic resonance imaging
NaPM	Natural Scientific, Psychoanalytical Model of the Psyche
NPyG	Natural Scientific, Psychoanalytical Glossary
PC	Personal computer
ROM	Read-only memory
SiMA	Simulation of the Mental Apparatus & Applications
tUC	Technical use-case
TU	Technical University
TPM	Thing presentation mesh
UC	Use-case

Specific Definitions for the Presented Scientific Treatise

Terminology: During the course of our research efforts, various terms had to be redefined when axiomatic contradictions arose. For this reason, the definitions of some terms in early thesis papers differ from their current ones.

Footnotes: In general, footnotes are avoided in the engineering sciences. Dietmar Dietrich however is convinced that in this particular case, where two completely different scientific fields are merged together, there is so much need for explanation between the disciplines that additional information must occasionally be provided which would interrupt the ongoing train of thought. In such situations, footnotes are a suitable tool for maintaining an unbroken flow in the main text body.

Words in italics: These words have a distinct meaning within the treatise or are the names of institutions, companies, etc.

Words in quotation marks: These words are understood differently by the various authors.

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1. Introduction

Technology has brought forth various impressive developments using nature as a template. Much has been written about even in popular science literature, for instance in the field of bionics [Blu 05; Bru 08]. The term bionics refers to the application of systems and methods found in nature to engineering design (in fact, the German term *Bionik* is considered a portmanteau of the words "*Bio*logie" and "Tech*nik*", meaning biology and engineering). It is interesting to note in this regard that much research has been conducted in mechanical and chemical bionics, but comparatively little in the field of information theory. While the reasons for this distribution are debatable, it is clear that biology has plenty to offer in terms of information theory: Excellent examples were compiled by Norbert Wiener, who recognized feedback mechanisms in biology which are used in the modern science of control theory. More recent examples are control principles in aviation, where mechanics are progressively being replaced by fieldbuses, first implemented in the Airbus A320 with its Fly-by-Wire technology providing a decrease in fuel consumption of up to 30% [Die 84].

With communication and computer technology dramatically on the rise in automation, requirements and the associated challenges have likewise increased. Many of these requirements could not be met using classic methods of purely mathematically oriented control engineering, which resulted in the inception of the field of artificial intelligence (AI) around the year 1955. Many fantastic developments have been made since then; the internet would not be possible without AI, for instance. But still there exists to this day no robot that can prepare coffee in the kitchen and serve it. We must try to understand what has gone wrong with regard to *complex* processes[5] until now, and what strategies and methods should be applied in future.

According to [Pal 08, p.9], the historical development of AI can be separated into 3 phases. The first can be described as the phase of *symbolic AI*, in which the main focus was on the symbolization and manipulation of data. In the second phase, that of so-called *statistical AI*, researchers learned to deal with learning and neuronal networks. The third phase was a crucial one in that the previous dualism was overcome in favor of monism by articulating that intelligence has to do with a physical body, and that these two entities cannot exist without each other. This is a pivotal step that many

[5] In this context, the term *complex* process should be taken to mean a process which is not completely describable despite a high level of abstraction, whereas *complicated* merely means that the required calculation effort for a process is very large. However, the presented scientific treatise will not adhere to this definition consistently and axiomatically.

researchers in the humanities, but also in the natural sciences, still refuse to accept. The decisive topic in this phase is that of behavior-based AI – also known as *embodied intelligence*.[6]

Several years ago the fourth phase was initiated, and its essential concept is that of *emotion-based AI*. In parallel, brain researchers like Solms [Sol 04] and Damasio [Dam 08] have made history by presenting a completely new way of thinking based on the realization that logical thinking is not possible without emotions and feelings. One must also keep in mind that a much earlier publication by Sigmund Freud [Fre 01, p.122] already includes his hypothesis as a neurologist and brain researcher that the handling of language, its creation and comprehension, is only possible on the basis of psychic processes. Word presentations play a determining role in the process of contents rising into awareness, and language thus cannot be viewed as a *function* localized exclusively in the brain.[7] Sigmund Freud already understood that consciousness, words, feelings and logic involve concepts that cannot be separated from each other.

All of these considerations finally caused Dietmar Dietrich [1] to initiate a new research project in 1999, which he first introduced internationally in [Die 00] and which was later given the name ARS (Artificial Recognition System) [3], then rechristened to SiMA (Simulation of the Mental Apparatus & Applications) in 2015. It is intended to herald the fifth phase in the development of AI. What are the fundamental methods that have to form the base of a design for an intelligent system in order to achieve this paradigm shift?

1. Computer engineering, chip development, developments like fieldbus technology or cyber-physical systems generally employ top-down design. This means that for each design, the process and the requirements for the control unit of the process to be controlled must be abstractly worked out and iteratively refined.
2. According to [Br 04], the pivotal aspect is to describe control systems on the basis of functions and not on the basis of their *behavior*. This also applies to chip design and requires a functional description that can be deduced from the *behavior* description.
3. In order to understand a *complex information* system, one must differentiate it into *functional layers* whose interfaces with each other must be unambiguously defined. This is a fundamental principle in computer engineering; computers cannot be understood without this *layered model*.
4. The control unit or regulation mechanism for a *complex system* is generally characterized by the fact that conflicting input information that is provided must lead to a *distinct target function* for the adjustment of output values.
5. The information arriving from the outside – as well as information activated internally – is constantly altered by the various valuation parameters (this process is known as *cathexis* in

[6] This may be understood better by reading [Yal 13], which is less scientific and much easier to read.

[7] It is important to be fully aware of the significance of this statement. It would mean, for example, that automatic language recognition could only be achieved in a quality akin to human capabilities if we were able to teach machines the ability of consciousness. To substantiate this statement should be a further goal of the SiMA project.

psychoanalysis). This means that every time a piece of information is accessed, a new valuation (cathexis) takes place and the result is stored appropriately.

Simultaneously, we intend to use a bionic approach with man as its focal point – for a simple reason: To this day, the final decision in most critical processes always falls to humans – in the piloting of planes, the driving of cars (at least within cities), the monitoring of airports any many other areas. This is because man with his nervous system and therefore his biological intelligence possesses abilities that we have not yet been able to reproduce in technical systems. It is important to recognize and understand this. The precise reasons why psychoanalysis was chosen for the bionic approach in SiMA will be elucidated in a later chapter.

2. Hitherto Completed Dissertations

Thus far, 13 researchers at the Institute of Computer Technology of the Vienna University of Technology have undertaken to write and finalize PhD theses on topics from the SiMA project[8]. What constitutes the principal difficulties and challenges in regard to such treatises?

The topic itself is highly interdisciplinary. On the one hand, it requires excellent knowledge in the field of computer engineering if it is to be tackled from a technical perspective. As explained later in Chapter 5, however, engineers generally lack psychoanalytical knowledge. The additional formal education of an engineer in psychoanalysis is unfortunately not practical, as sources indicate that such an education in this field would take up to 10 years, and even then would not qualify the graduate as a researcher. This means that the task we have set out on cannot be accomplished without full-fledged scientists from computer engineering and psychoanalysis, and is the reason why several psychoanalysts are permanent or temporary members of the SiMA project team. Among them are international experts like Elisabeth Brainin, who helped to lay the project's foundations [Bra 04.2], as well as advisers like Mark Solms [Sol 04] or Georg Fodor [Die 09.1], who helped to initiate the International Neuropsychoanalysis Society [4] and hold important offices there. They have been counseling the project since 2005, which is why the first dissertations presented in the following have not been revised by psychoanalysts.

All hitherto published dissertations were written by engineers of the Faculty for Electrical Engineering and Information Technology and the Faculty of Informatics.

The respective *modified* (for brevity) abstracts are put into perspective and *commented upon* in additional notes written by Dietmar Dietrich[9].

[8] All PhD theses presented in the following were written in English. In order to achieve a homogeneous written version, however, this entire treatise was written in German in several iterations before being translated into English by Stephan Stockinger.

[9] These abstracts show clearly how knowledge and awareness have changed and developed throughout the course of the SiMA project. While there were many issues to be resolved in the beginning, the fundamental complex of questions faced in the project became increasingly apparent over time, and its foundations were developed successfully. SiMA slowly obtains a clear-cut and recognizable shape – and continues to do so as work goes on. Over the years the project members have learned which important principles must be observed and what the next goals must be. In this way, each dissertation in SiMA has taken the project one step further forward, and without these thesis papers SiMA would not have been possible at all. That we as a team have come so far is owed largely to these dedicated researchers.

2.1 Situation-Dependent Behavior in Building Automation

Shortened and modified abstract of the dissertation by Gerhard Russ (defended on 7/1/2003) [Rus 03]

The focus of this treatise lies on automation in buildings. A multitude of ready-to-use systems for various applications is available in this area, but most of these systems are completely self-contained, thus preventing the creation of overarching functions. Furthermore, current building automation systems consist of purely reactive systems, i.e. they react to inputs only if the relevance and influence of the respective data have been explicitly predefined. Other factors not directly associated with an application are simply ignored, meaning that unexpected situations may lead to erroneous or erratic behavior or actions.

The goal of this thesis is to develop a model than can fulfill the demand for a system capable of dealing with the *complex* situations of modern life by allowing *conscious* situational recognition and "proactive" measures. This requires the integration of various existing technologies as well as efficient processing of huge amounts of information. Biological systems and principles have often proved to be reliable and suitable patterns for technical developments in the past. Therefore, the main focus of the treatise will be the integration of biological concepts.

Additional Note

The goal definition originates from building automation in combination with the notion that, in future, hundreds of thousands of integrated sensors will continually be providing data to be processed.[10] While the work builds on the idea of the layered model [Rus 03, p.40, p.112], by today's improved understanding of psychoanalysis the three pivotal methods described in Chapter 1 of this thesis are not consistently applied: The top-down design principle is not strictly followed[11], with traditional technical AI thinking being used instead[12]. The decisive point about this thesis, however, is that it is the first to identify the problem areas from the perspective developed in [Die 00]. Russ discusses, differentiates and juxtaposes terms like *image*, *motion* and *act* [Rus 03, p.94] which were only clearly defined in later development stages of the research project. He likewise addresses the question of what the term "forget" mean in humans? Russ also deals with semantics [Rus 03, p.100] – albeit without considering the psychoanalytic aspect, since we as a team did not yet realize this correlation at the time and were thus unable to verify the interoperability of our various research results. This will be discussed in more detail later in this report.

[10] What constitutes the current state of the art can be determined e.g. from [8].

[11] See e.g. [Rus 03, p.57ff.]: Great significance is attached to the sensor layer; only later are the higher layers discussed, which makes perfect sense from an industrial perspective.

[12] See e.g. [Rus 03, p.70].

2.2 Automation System Perception – First Steps Towards Perceptive Awareness

Shortened and modified abstract of the dissertation by Clara Tamarit Fuertes (defended on 7/1/2003) [Tam 03]

The term "perceptive awareness" originates from a bionic approach to the improvement of the behavior of automatic systems. Based on human behavior, this thesis focuses on designing a new automation model, a tool to assist in developing networked automated systems. This new model is designated Perceptive Awareness Model (PAM). Requirements are increasingly arising in building automation that can no longer be fulfilled with existing tools and technologies, and PAM provides a new approach to these issues.

Based on the principles of the ISO/OSI model, PAM not only deals with the actual communication between units but goes one step further: It encompasses the entire aspect of information processing in order to achieve preventive behavior by the system. One prerequisite for the model is its compatibility with modern technologies in automation and tools for the implementation of those systems. Furthermore, the model supports the integration of additional applications like image or sound recognition to provide improved perception of the environment. Hence PAM offers a new concept in automation based on the principles of nature.

In contrast to modern automation systems which respect only certain inputs, humans consider a situation in its entirety. In order to achieve similar behavior in automatic systems, the first step in the new model consists of collecting a large amount of data on the surroundings. This information is then processed in several steps to allow the recognition of situations and, eventually, preventive behavior.

Following the development of the model for perceptive awareness, the thesis' main focus is the perceptive capability of the system: image processing systems with IEE 1394, sound recognition with Voice Extreme by Sensory, and fieldbuses like LonWorks for detecting and/or controlling different environmental parameters are integrated into the system.

Additional Note

As opposed to the previous dissertation, Tamarit concentrated primarily on the development of a complete model and its practical coupling with industrial communication systems (fieldbuses, interface tools etc.). Concrete topics like profiles of fieldbus technology and inter-industry functions are discussed; Tamarit separates her model into many sub-layers, which shows her interest in industrial application as well as proving how complex and intensely problematic the topic is: It is so broad that it must be disassembled into several scientific sub-projects. Tamarit's work was pivotal for the directions taken by several following dissertations, i.e. for deciding which topics were to be tackled more or less independently of each other at first.

2.3 Processing and Symbolization of Ambient Sensor Data

Modified abstract of the dissertation by Gerhard Pratl (now: Gerhard Zucker) (defended on 4/27/2006) [Pra 06]

Building automation is progressively becoming an integral part of our daily life. Systems capable of assisting humans more effectively allow new services to be provided. One challenge in the development of such systems is the ability to observe objects, events and situations in a manner similar to human perception.

In this thesis, a model is defined based on the adaption of neuroscientific, psychological and psychoanalytical models. Data originating from diverse types of sensors are symbolized, processed on several levels, and the information relevant for the system is extracted. The foundation for this process is the application of knowledge gleaned by research into human perception, and its result is a symbolic representation of the world which is used to recognize motions, i.e. temporal sequences of events. As the main focus of this treatise is on perception and observation, actions and reactions play a subordinate role, though they are of course intended as a consequence for recognized motions. The symbols defined in this work are connected to the real world in which the system operates (grounded symbols), an aspect achieved by correlating the bottommost layer of symbols with sensor data from the real world.

Additional Note

This dissertation initiated a new phase, the second phase of the SiMA project as seen from today's point of view. While the two previous theses included psychoanalysis only as a notion, not as a consistent concept, and were still heavily grounded in the thinking of classical AI, it is obvious that Pratl contemplated the new ideas and discussed them intensively with his colleagues. He differentiates clearly between what happens on the hardware layer, the symbolic layer (technically speaking), and in the psychic apparatus. He is the first to use the term "grounding", and develops model concepts of perception, e.g. regarding how humans perceive velocity, something that had not been conclusively portrayed elsewhere before.

2.4 Probabilistic Models in Building Automation Recognizing Motionswith Statistical Methods

Shortened and modified abstract of the dissertation by Dietmar Bruckner (defended on 1/23/2007) [Bru 07]

Building automation systems with a large number of parameters are difficult to describe with common methods. In other words, it is difficult to interpret in an automated fashion the processes – the context – which lead to specific situations within a building.

This thesis investigates to what degree human behavior can be appropriately measured and interpreted using statistical methods. A hierarchical model structure based on hidden Markov models is defined as a framework and evaluated in comparison with other models.

In the thesis, three implementations of individual aspects of the complete system are put forth: Bruckner initially shows that the use of simple statistical models for the description of sensor behavior provides advantages for the user of the building automation system in regard to the accuracy of alarms. The second implementation shows that the model structure is suitable for modeling the behavior of a collective system in a highly abstract fashion. One concrete application of this idea – monitoring the traffic situation in tunnels – is presented. Finally, Bruckner explains how a hidden Markov model in combination with appropriate models for the sensors can be used to find patterns in sensor data. These patterns are represented within the model structure in a way that allows a human to interpret states of the model – or combinations of states – semantically. This principle can be used as a basis for future systems capable of recognizing the situation of the human user.

Additional Note

Bruckner cooperated with the Austrian Institute of Technology, which at the time was called the *Austrian Research Center Seibersdorf*, while writing his thesis. The business area Neuroinformatics was subsequently founded at the Institute’s Information Technology department and Bruckner worked there for some time.

This thesis should not be viewed as a sequential research paper within the SiMA project, but by contrast attempts to measure neurospecific and psychoanalytical principles of human behavior in a purely statistical fashion. Hence such concepts are based on bionic ideas, but search for exclusively mathematical solutions. This is necessary for a number of reasons. From an economic point of view, the most efficient approach possible must be found for concrete applications. Bionics under consideration of psychoanalysis is fundamental research. The SiMA project, however, intends to accomplish both – to conduct basic research on the one hand, and develop economically and technically feasible engineering concepts on the other. Bruckner’s work thus achieved a further goal by developing a principle that is not only already industrially applicable today, but which future specific SiMA solutions can be compared to and evaluated against.

2.5 Adaptive Behavior Arbitration for Mobile Service Robots in Building Automation

Shortened and modified abstract of the dissertation by Charlotte Rösener (defended on 7/25/2007) [Roe 07]

There is a trend in building automation and robotics towards increased integration of sensors which, combined into progressively more complicated surveillance systems, are capable of achieving ever more precise descriptions of the processes they monitor with the help of mathematical methods. This evolution has massive consequences for the development of new methods in system control. The presented thesis describes a functional model which attempts to improve the autonomous behavior of technical control systems by way of emulating internal mechanisms of human behavior on the basis of knowledge from psychoanalysis and cognitive science. In contrast to other research projects attempting to emulate observable intelligent behavior directly without knowledge of mental processes, the goal of this work is to describe the decision-making process of the human mind in its functionality in order to achieve decision-making and autonomous behavior in technical systems. Based on extensive discussion of the effects of perception, previous semantic knowledge, inner conflicts, and memory on the decision-making process, functions for decision-making are developed and described in a model. In order to allow qualitative statements about the effectiveness and correctness of the model, a game-like testing environment is created in which two groups of robots with identical physical properties but different mental capabilities compete for limited energy resources. The results of the simulation show a noticeably higher chance of survival for the robots with greater mental capabilities.

Additional Note

The work was conducted in part at the Institute of Computer Science at the TU Vienna, but Rösener also spent one year at the *Department of System Design Engineering* in Yokohama, Japan; this fact becomes apparent in her thesis. For the first time during the SiMA project, Rösener placed a focus on independent systems, which after completion of the 11th dissertation within SiMA has ultimately led to the previously mentioned *use-cases*. It became clear that human intelligence truly cannot be defined without a mobile body, and that any attempt to do so leads to a multitude of contradictions. Thus Rösener initiated the third phase of the SiMA project, a pivotal development which opened the door to a new way of thinking – a new dimension. For intelligent systems, the social relationship between the intelligent objects is a necessary requirement.

Another issue became obvious with the results of this work, however: The approach encountered by Rösener in the Yokohama robotics laboratory in regard to robotics models applied there is not compatible with the psychoanalytical way of thinking. Robotics at the *Department of Systems Design Engineering* – and this statement can be applied worldwide – sees the behavior of humans in their appearance, their movements, etc. and tries to interpret and emulate it. The SiMA team follows a completely different way of thinking: The engineer lacks the decades of experience of a psychoanalyst[13] and should therefore concentrate on his own abilities. Over the course of 100 years, psychoanalysts have developed a model of the psychic apparatus; why not adopt this model as an engineer, instead of arrogating to be able to develop a better one? The job of the engineer is to prove that he is capable of implementing natural scientific models of every kind, i.e. to simulate and emulate. And there is a further problem: That a robot’s outer appearance is similar to that of a human does not by itself endow it with *humanness*. Humanness is characterized by conscious and unconscious thinking, i.e. a high degree of intelligence, which is something that cannot be attributed

[13] The training to become a psychoanalyst in Vienna takes between 6 and 10 years at either of the recognized psychoanalytical schools, the WPV and the WAP. Completion of such a course, however, does not yet qualify one as a scientist.

to any currently existing robots. While they may look and move like humans, there is nevertheless nothing human about them in a humanistic sense.

2.6 Interpretation of Situations in Buildings

Shortened and modified abstract of the dissertation by Wolfgang Burgstaller (defended on 11/29/2007) [Bur 07]

The presented thesis describes a system for recognizing predefined situations in buildings. The definitions of these situations occur on the basis of several abstraction layers of likewise predefined symbols, a structure modeled on the human brain. Based on the findings of neurologists, neuropsychologists and neuropsychoanalysts, a technical model of symbol hierarchies and valuation mechanisms was developed. Like in humans, the presented approach collects data at the periphery, separates them into known units and compares them with known patterns in order to recognize situations. In a separate spin-off project, the recognized situations are used as the basis for decisions regarding the interactions of the system with its environment.

In modern building automation environments, fieldbus systems are used to network components; these fieldbuses then send their data to higher layers in the automation pyramid for the appropriate information to be extracted. The goal of this thesisis to implement the abovementioned principle.

The system thus developed can therefore be considered an advancement in building automation. It not only allows control tasks to be fulfilled, but far more complex situations to be registered and influenced, and corresponding applications to be realized. The applications on which this work is focused are e.g. recognition algorithms for fallen humans and dangers to children, as well as systems to determine the locations of humans. These applications were developed as prototypes. To ensure that the defined motions can be recognized, it is necessary to equip buildings with a large number of redundant and diverse sensors. As this cannot be effectively realized at the current time, a simulator is used to verify the concept along with a physical test assembly in a single room. The simulator allows sensor data to be generated based on a defined virtual environment. Although the system presented herein is focused on building automation, the concepts can in principle be applied to all areas of automation.

Additional Note

The presented work shows conclusively how the nervous system, of which the brain is a part, can be separated into different abstract layers in order to better differentiate and understand its interrelations and functions. The thesis points out the levels in the symbolization layer as well as the formation of all symbol levels from lowest to highest. It also shows what an extensive structure the system will become if one attempts to implement all the possible functions of a human being; from today’s point of view, the *complexity* would be absolutely monstrous. Therefore, drastic simplification – especially in the current situation of the first steps in this research topic - and abstraction are obviously necessary.

The thesis also has a practical orientation, demonstrating clearly that practical implementation can only be achieved in a very limited scope with the means available at the time. Burgstaller's work was the deciding factor for the decision to split the project's development into two layers (and thus into at least two research groups): That of the psychic apparatus and that of symbolization, i.e. all the abstract functions which lie below the unconscious. Furthermore, it became apparent that a practical realization would be financially unachievable by the Institute of *Computer Technology* of the *Vienna University of Technology* alone, and that therefore simulation would have to be used exclusively in future (which from the point of research is not a problem, but has a greatly reduced public image effect).

2.7 From Neuro-Psychoanalysis to Cognitive and Affective Automation Systems

Shortened and modified abstract of the dissertation by Brigitte Palensky (defended on 2/22/2008) [Pal 08]

Complexity, the desire for more process information, greater required dynamics etc. are pushing the limits of traditional, rule-based control system. New adaptive and flexible solutions will be required in the future. This thesis describes a new approach for equipping technical systems with the cognitive abilities of the human mind. A central point is the holistic view of perception and action held by psychoanalysis with regard to humans. Automation systems or robots are furnished with affective mechanisms of valuation (drives, emotions, wishes, etc.) which allow them to convert perceived sensor data into information carrying a meaning and context-specific knowledge, which in turn is the basis for the selection of appropriate actions. The core of this architecture is a memory unit that stores individual experiences of a system in an emotionally valuated fashion. The constant flow of perceptions is filtered by these valuated memories of events and own actions, including their consequences, in order to determine high-value decisions for the current situation. Experiences which were perceived as pleasant in the past, and decisions which indirectly led to positive feelings, are striven for again. Previously experienced and stored sequences also serve to anticipate the outcome of current processes and influence them for the system's own benefit. The influence of the chosen neuropsychoanalytical approach on the design of the cognitive architecture is examined in terms of its constituting elements (concepts, functions, data structures, etc.) as well as in terms of its structural organization and the processes taking place on it. Initial prototype tests of the new concepts are described in order to demonstrate how the individual parts of the multi-layered architecture interact and affect each other during operation. A future complete implementation of the architecture promises to allow technical systems of this type to develop, despite the high levels of complexity, not only a context-sensitive understanding of their environment, but also an image of themselves as acting entities.

Additional Note

This thesis was compiled with painstaking precision. It was probably also the treatise within the SiMA project that most thoroughly discussed the history pertinent to SiMA. Chapter 2 is therefore encouraged reading for any scientist active in this field. It shows the different phases of artificial intelligence and evaluates them from a current perspective.

As the recent developments in SiMA clearly show, we were heavily burdened with legacy problems which were fortunately exceptionally well identified in this dissertation. Now the central question became evident: How can we consolidate psychoanalysis with the function of memory? Palensky's work illustrates that this goal can only be achieved through different (*functional*) layers (see e.g. [Pal 08, p.75]). It also demonstrates that the connections between the *functions* become more and more complicated and *complex* and will ultimately lead to descriptions in which the interoperability between *functions* must be revised from our current point of view. Palensky thus contributed significantly to the new course subsequently taken by SiMA.

2.8 A Bionic Model for Human-Like Machine Perception

Shortened and modified abstract of the dissertation by Rosemarie Velik (defended on 4/25/2008) [Vel 08]

"Machine perception" is a young area of research confronted with many unsolved problems. In contrast with machines, humans can generally perceive their environment without great effort. These two facts were pivotal for the decision to develop a bionic model for human-like perception in the presented thesis. The model is based on neuroscientific and neuropsychological knowledge of the structural organization and function of the human perceptual system. A technical system with human-like perceptual capabilities would allow the automation of a myriad processes which hitherto require human observers and their cognitive abilities. Potential areas of application are security surveillance in public and private buildings or monitoring the health of patients in hospitals or retirement homes. Autonomous robots and interactive environments would likewise profit from more effective mechanisms for perceiving their surroundings. Such systems would have to be equipped with a multitude of different sensors, and the challenge lies in combining and interpreting the information from these sources. To do so, a principle of information processing referred to as neurosymbolic information processing is introduced. It uses neurosymbols as elemental information processing units, a concept inspired by the fact that humans think in terms of symbols which, however, are the result of neuronal information processing. In order to process sensor data, neurosymbols are connected in a so-called neurosymbolic network with a modular and hierarchical structure derived from the human perceptual system. Connections and correlations between neurosymbols can be established from examples in a series of learning phases. Besides the processing of sensor data, the mechanisms of memory, knowledge and focus of attention have influence on perception in order to handle ambiguous sensor information and concentrate processing power on relevant features. The presented model was implemented with AnyLogic and proved successful in recognizing the specified test cases. Furthermore, the insights gained during development allowed inferences about the incompleteness or inconsistency of certain neuroscientific and neuropsychological model concepts, e.g. in regard to the so-called Binding Problem, the processing and storing of perceptual images in general and location information in particular, and in terms of stability.

Additional Note

For the first time in the course of the SiMA project, Velik's dissertation deals exclusively and in detail with the second layer of the model, i.e. the layer between the physical description (layer 1) and the layer in which the psychic apparatus is represented. This is the layer about which practically nothing is known. Velik examines and discusses the reasons for this lack of knowledge, entering uncharted scientific territory and proving the feasibility of modeling this layer – an outstanding scientific accomplishment and a true worldwide first. To achieve this she introduces the term neurosymbolization, derived from the field of neuronal networks in which she had previously been active. It must be noted that this model is a purely *functional* one, meaning that as per the Mealy Machine model it describes an (abstracted) layer lying above the layer of the hardware, e.g. that of neuronal networks or another type of hardware, and below that of the primary process[14].

2.9 A Decision Unit for Autonomous Agents Based on Modern Psychoanalysis

Shortened and modified abstract of the dissertation by Roland Lang (defended on 1/12/2010) [Lan 10]

One of the greatest challenges for modern computer systems is posed by applications occurring in the real world. Current applications in artificial intelligence still show considerable deficits when applied to such real world motions. Following a bionic approach, models of human perception and decision making are sought in order to improve technical systems with the insights thus gained. A consistent model still does not exist, however. The presented thesis describes the model of a decision unit for an autonomous agent, restricting itself to a specific concept of the human psychic apparatus, namely that of metapsychology. Its theories are neither adapted nor developed further in the treatise, but instead examined and validated from a technical perspective in terms of their usability, implementability and realizability within the framework of a decision unit for autonomous agents. The structures of the psychoanalytical theory are analyzed and implemented technically in the decision unit of an autonomous agent corresponding to the model. While methods of classical artificial intelligence are used in this process, they are controlled by the superordinate, psychoanalytically inspired model and must conform to its constraints. Application of the agent in a simulated environment demonstrates the strengths of the system, especially in terms of data interpretation and valuation on the basis of internal and external performance indicators.

Additional Note

Lang's thesis initiated the fourth phase in the SiMA project. For the first time, two challenges were met which clearly determined the subsequent course of action: On the one hand, Lang had managed

[14] Form the point of view of psychoanalysis, this area lies below that in which information exists unconsciously and above the layer of the neuronal networks.

to meticulously break down the model – starting from its topmost layer (the functions of the id, ego, and super-ego) – into many submodules in several layers. Thus the complicated model from psychoanalysis was given a clear structure for us engineers for the first time. Lang was able to explain the tasks of the various submodules, though as a result of the sheer effort required, he could not describe each one in detail or completely code them all. Instead he focused on a few functions in detail, developing others only in a simple form or even as dummies. The differentiation into primary and secondary process was precisely defined and the necessary data structures were established.

The second challenge was this: How can the complicated system be brought into a state in which it does not immediately come to a standstill or begin to oscillate after its initiation due to incorrect parameters? The test results are quite basic, but nevertheless show the potential that the model can achieve in principle, and the challenges and tasks for the following theses became immediately apparent.

2.10 Bionically Inspired Information Representation for Embodied Software Agents

Subtitle: **Realizing Neuropsychoanalytic Concepts of Information Processing Within the Computational Framework *ARSi10***

Shortened and modified abstract of the dissertation by Heimo Zeilinger (defended on 12/3/2010) [Zei 10]

The topic of this thesis is the bionically inspired representation of information in the control unit of a software agent. The central issue is the technical implementation of neuropsychoanalytical concepts for the generation and processing of mental data structures, which is juxtaposed with established bionically inspired approaches. This represents a new path in artificial intelligence intended to allow implementation of the control principles of the human mental apparatus in technical systems.

The concept features an existing decision unit which is augmented by an information management system comprising information management functionality and a data storage. The adaptations resulting from this expansion are defined using a top-down design approach in a model whose implementation produces the technical framework *ARSi10*[15].

Realization occurs in embodied software agents. The *Bubble-World-Simulator*, based on a multi-agent simulation system, is developed as a testing environment in which the agents' behavior can be evaluated via defined use-cases. Evaluation occurs by means of internal and external performance indicators which show the strengths of the developed system. Information from internal and external

[15] To differentiate it from the many existing previous versions of the software programs, Zeilinger began referring to his version as ARSi10 since it was developed for the 10th SiMA thesis. This versioning nomenclature was continued by the subsequent thesis authors.

sensor data is represented in neuropsychoanalytically inspired data structures and used for the decision making process. This allows interaction of the agents with their environment, with the main focus being the balance between system resources and functional capability.

Additional Note

In the dissertations preceding Zeilinger's, the difference between functions and *data* and the correlation between these two terms and the term *behavior* was clearly defined (Freud had only known the term *function*). The *data* types had previously not been specifically examined in scientific treatises within SiMA, and Zeilinger dealt with this topic in particular. In the SiMA model, data reach the third layer – the psychic apparatus – via the second layer as symbols, images and motions. In the psychic layer, they are valuated by means of quotas of affect, emotions and, finally, feelings. The *symbols*, *images* and *motions* are manipulated (modified) as objects (things) in the *functions* via internally stored objects, and new *symbols*, *images* and *motions* are developed as well. In the primary process, Zeilinger referred to them as *thing presentations* since in this *functional* area they are not connected to human language; they are however heavily cross-linked, resulting in *thing presentation meshes*. Word assignment only occurs at the transition to the secondary process, where every object (*thing*) is associated with a *word*.

In this context a fundamental question had to be answered which to this day is misunderstood or not even recognized by many scientists, a fact which also led to the essay by Dietrich countering statements by Leuzinger-Bohleber [Die 12]: What is the connection between the psyche and the stored data? Placing the databases into the third layer, the psyche, is principally wrong because the third layer represents an abstract layer that can have nothing to do with *hardware-like* data storage. In the end, there is only one solution: If one imagines the three-layered SiMA model spread out into a two-dimensional plane, the data structures must be seen as an orthogonally placed second plane of three layers. Thus in the SiMA model, input data flows through the first and second layers into the third layer, the psyche, and back down from there. Simultaneously, the third layer stores data in the hardware via a second orthogonally oriented layered model, and can access data via these layers as well. This model also answers repeatedly asked questions about the contradiction that while the data storage must be viewed like a ROM in terms of hardware, it can simultaneously be stored and searched associatively. The reason is that the ROM function is located in the bottommost layer and the associative function in the layer above it. How this double-layered problem is resolved in terms of the brain's hardware is immaterial to the psyche according to information theory, so long as the performance and thus the interface requirements between the layers are met.

Zeilinger thus approached fundamental questions which had never before been so excellently and painstakingly dealt with in this context. The thesis is naturally quite difficult to read for psychoanalysts and neurologists, but one must understand that the author achieved something for which a model had been sought after for many years. Furthermore, he was able to validate it in a very comprehensible fashion with his simulation experiments.

2.11 Human Bionically Inspired Autonomous Agents

Subtitle: **The Framework Implementation ARSi11 of the Psychoanalytical Entity Id Applied to Embodied Agents**

Shortened and modified abstract of the dissertation by Tobias Deutsch (defended on 5/23/2011) [Deu 11]

Computers interacting with complex systems (e.g. in building automation) face the challenge of having to process large amounts of data. In addition, their control systems must be capable of executing this data processing in real time. Classical artificial intelligence offers no appropriate solutions for this problem, as classical AIs are conceived for isolated tasks and cannot be easily integrated into larger more powerful and universally applicable control facilities meeting the requirements of complex systems. In contrast to such classical AI, the presented thesis uses a bionic approach by examining a model of the human psyche in regard to its technical applicability on the basis of the metapsychology of psychoanalysis. The developed model is implemented using agent technology for evaluation, with the implementation of the Freudian id and its interrelation with a body, the embodiment, forming the central topic. The agents must complete several test cases in a varied and dynamic simulated environment, and the behavior demonstrated by the individual agents in the simulation is analyzed. It can be shown with the help of this testing environment that the newly introduced concepts (the seeking system, improved separation into libidinous and aggressive drives, and the significance of the body and its internal systems) can be implemented in keeping with the initial propositions. The developed model is part of a program focused entirely on basic research and offers a new concept for the process control of complex systems.

Additional Note

Deutsch was able to achieve several goals of the SiMA project simultaneously. Already after only a few dissertations it had become obvious that the definition of axioms would play an important role. This makes sense, as computer technology is unthinkable without them – one need only think of the many standardization committees in the various industries in which the computer's role is constantly gaining in importance. In the SiMA project, however, we had initially thought we could conduct our research without doing so, and could in some way deftly sidestep this important task. Deutsch took up this serious problem and developed an excellent solution for it which the subsequent work had to integrate. The topic of axiomatics will be discussed in more detail in a later section.

Since the dissertation by Lang (Chapter 2.9), the functions in the primary and secondary process were more or less known, but it was Deutsch who synthesized in detail the functions of the id in cooperation with the psychoanalysts on the SiMA team. He showed how the libidinous, aggressive and other dimensions of drives are to be understood from a natural science point of view. What role do they play in a *complex* control system? The clear-cut and precise top-down differentiation illustrates for the first time that the seemingly complicated structure of the functions of the psyche allows a many-levelled evaluation system which considers for all its decisions not only multiple simultaneous action goals, but also all the varied experiences made in the course of a lifetime.

A further outstanding aspect of Deutsch's thesis must be emphasized: According to computer theory, it is vitally important in a top-down design to ascertain, what the *top* function in the modelis. Great store has always been set by this in the SiMA project, but how can we actually validate our *top function*? In technical systems, this validation usually does not represent a problem: Validation values are the requirements posed to the respective device. The experiments conducted by Deutsch made it apparent for the first time that things are not so clear-cut in SiMA, for the use-cases are developed by psychoanalysts and rewritten into simulation requirements in cooperation with engineers, and these engineers – in this case Mr. Deutsch – can only validate the results of the simulation experiments on the basis of the technical and natural scientific description. This raises a point that will have to be critically examined within the SiMA project.

2.12 Human-like Perception for Psychoanalytically Inspired Reasoning Units

Subtitle: **Perceptual Information Processing Concepts Realized in the ARSi12 Framework Implementation**

Modified abstract of the dissertation by Clemens Muchitsch (defended on 11/19/2013) [Muc 13]

Architectures of artificial perception deal with problems which are easily solved by the human brain. The advantage of human perception lies in the combination of information from various sensory sources with previously experienced perception memories, which generates a multimodal and subjectively consistent view of the world. While insights into the functionality of human perception expand the possibilities of cognitive architectures, a holistic view of human perception and cognition in artificial technical agent architectures has yet to be examined.

The presented thesis describes a bionically inspired framework of perception in a control architecture for embodied software agents. The focus is on the realization of neuropsychoanalytical concepts for the processing of mental perception data. This new approach for artificial intelligence allows the modeling of perception functionalities inspired by the human psychic apparatus in a cognitive agent architecture.

The existing control architecture was expanded through the examination of the perception-action-cycle in a top-down modeling approach, and the resulting adaptations implemented in the embodied agent framework ARSi12. The resulting model shows how data from a multimodal sensory system are condensed into mental data structures and associated with the knowledge of the individual agent, and how this information contributes to the decision-making process.

Use-cases are employed to assess the abilities of the agents within the artificial life multi-agent simulation ARSin World developed as a testing platform for evaluation of the functional model and the decision unit.

Additional Note

Muchitsch possesses a meticulous and distinctly engineering way of thinking. From the very beginning of his thesis he places great emphasis on clearly derived axiomatics and consistently executed top-down development, with possibilities for evaluation distinctly provided from the start. He fastidiously ensures that the incompatibilities between the various psychoanalytical schools of thought have no consequences within SiMA, and that the employed methods are concisely described and therefore understandable to everyone. For the first time, the sequences in the primary process are analyzed in detail and synthesized according to the use-cases – though due to the required effort, Muchitsch reduces the defense mechanisms to the necessary minimum. This strict and consistent approach leads to decisive improvements in the clustering of functions and the analysis of data structures passing through, thus making the information flow in the brain better observable. The layered structure with all its interface descriptions is worked out brilliantly, and the technical and engineering analysis and preparation is outstanding. The consistent top-down design is so clear that hitherto existing weaknesses became immediately apparent as “gaps”. This made the necessary tasks in the various functions of the psyche easily visible and explainable, which in turn simplifies the development of the actual functionalities of these functions.

The consistent working out of all details of the SiMA model in this thesis ultimately resulted in a framework (simulation tool) which can now be worked on together by several further doctoral and master students as well as bachelor students. Muchitsch was able to consolidate the different theoretical aspects into a unified representation which forms a structural basis for further work. His thesis is highly recommended reading for anyone seeking insight into the conceptual world of SiMA, as well as for anyone who wishes to understand the underlying methods and principles it is based on.

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2.13 Generation of Inner and Outer Speech by Means of Situational Context

Modified abstract of the dissertation by Isabella Hinterleitner (defended on 09/04/2014) [Hin 14]

This thesis deals with the topic of semantic and situational context within the SiMA project. A context is required when agents communicate, and it is determined by a domain-specific ontology as well as a general ontology. Whenever the agents speak about something, it is necessary for them to be aware of the content-specific domain and possess specific knowledge about it. Different types of knowledge bases must be differentiated depending on whether the topics of communication are very specific or of a more general nature, with the latter case requiring a greater amount of abstract knowledge.

In order to determine the situational context, the agent calls up memories from his ontology and compares them to the current situation. If sensations of the current situation correspond to those in the stored memories, a situational context is created which allows the agent to navigate on the basis of this contextual help and to select from a range of actions associated with the context. Hence this situational context is a mechanism for actions like language use. For language, semantic context between two communicating agents can be created.

The result of this work is the generation of language based on a previously created situational context. A modular model from psycholinguistics is used for language production. This model is transferred to the SiMA framework in a heavily simplified form in order to provide the agents with (inner and outer) language capabilities. Thus the agents possess a language which is determined by their current situation, but is also capable via abstraction of producing language in new situations by seeking familiar structures in new patterns. The abstraction mechanism searches for congruence until something familiar has been found in a new situation. Once this is the case, familiar language statements can be transferred to a new situation.

Additional Note

The sole target of this thesis was to demonstrate the feasibility of integrating language in the SiMA project based on its current scientific state. The goal was to point out a possible approach and the difficulties associated with its implementation – a topic which no project member had hitherto addressed. Hinterleitner's efforts made this issue tangible and allow further steps in this regard to be planned. Taking into consideration the first major publication by Sigmund Freud, *On Aphasia* [Fre 01], it becomes immediately clear how important this topic is for the psyche, for there is no consciousness without language.

3. Information Theory and Psychoanalysis – Foundations of the SiMA Project

Information theory in general is a very broad field. Therefore, principal remarks regarding information theory of computer technology will be provided initially in the following before going into more detail on specific topics.

3.1 Principal Remarks

Newton and Leibniz developed infinitesimal calculus almost simultaneously. But bridges and buildings had been built successfully even before that time, while all modern calculations for construction engineering use infinitesimal calculus. A lot of time was required before this was accepted and, more importantly, understood. Radical new approaches are always only understood by few in their beginnings, while being misunderstood by many and rejected by most. Had Freud had access to the knowledge of information theory, he would have been able to answer many of his own questions he was forced to leave open. This is immediately apparent to any natural scientist reading Freud's first scientific work, On Aphasia [Fre 01]; I myself cannot imagine anything else. Had Freud known information theory, he would certainly not have claimed – as emphasized in publications by Mark Solms and Marianne Leuzinger-Bohleber – that the brain is not a computer; an assertion disagreed with by Dietrich, who discusses reasons to the contrary in [Die 12]. This (presumably scientifically unfounded) statement that the brain is no computer will also be discussed at length (and in a wholly scientific manner) in this documentation.

That information theory was not researchable prior to the age of computers cannot be proven, but I believe that the reader will agree after having read this chapter. Through computer technology, a new base for information technology was established; it is a fact that the computer was the first machine for extensive information processing. It provided for the first time ever the capability to develop a model of information theory element by element and simultaneously simulate and test it technically and hence practically (using physical building blocks).

The consequences are colossal. In the time that has passed since the introduction of computers, information theory has often asked questions like: How is knowledge generated? What are the underlying structures? How can knowledge be processed, stored and filtered? What are the structures of language? How did it develop and how is it developing in humans now? And many more. Today, computer systems make it possible for us to analyze these open questions and validate[16] them using physical building blocks. Proof is no longer an imperative; it is sufficient to be able to establish corresponding models and ultimately simulate and emulate them.

A further thought is of pivotal importance. The term *model* received a new dimension through the introduction of the computer. Previously, the following formula applied:

$$\text{Reality} = \text{Model} + \Delta, \qquad \text{(Eq. 3.1)}$$

where Δ stands for the difference. There is thus always a difference between reality and model, a fact which goes without saying in physics. In psychoanalysis, however, it must apparently be emphasized constantly, as the researchers in this field seem to think some engineers wish to assert that man could be described completely.[17]

In information theory, Eq. 3.1 can be changed by letting

$$\Delta = 0,$$

meaning that the model perfectly represents reality, i.e. there exists no difference between model and reality. As shown in [Kra 88], this can lead to a kind of megalomania, which appears to be the case with some computer engineers and information scientist. What does this mean?

Take the following example: in information theory, models of a database are possible – that is, structures can be thought out to detail how data can be organized and processed. This occurs on an abstract level which in principle can of course be created without errors. Here physics – with the computer a mere carrier of information – thus has no direct influence on the model, and indirect influence only in terms of performance or size. This allows computer engineers to conceive a model in a “godlike” fashion: They are able to implement their ideas in reality completely. But in the very moment when physics has to be taken into consideration in the model, i.e. when it transcends pure information theory, the “natural law” from Eq. 3.1 once again applies. And the equation also applies to the SiMA project, for the nervous system works in the realm of physics. For us engineers, this means that we must proceed in a natural scientific way in psychoanalysis for development of our model. Over the years, however, this fact has proven to be the source of enormous problems as illustrated in Table 3.1.

Table 3.1 lists examples intended to make clear the problems arising in interdisciplinary research. Computer technology uses well-defined terms like *datum* or *class* which are unknown in psychoanalysis. Conversely, the same is true in the reverse for psychoanalytical terms like the unconscious, psychic energy, etc. There are however many shared concepts which, while not being

[16] To what degree this validation will be possible has yet to be determined. It is also not important at this point to concretize how the physical building blocks are described, i.e. in terms of hardware or software or any other way.

[17] We as authors are aware that this is not a scientifically justified assertion, for we cannot substantiate it with a literature reference. We are confronted with these statements in workshops with psychoanalysts, where things are said that cannot be put down in writing in the same way. We have recorded some of these statements (not verbatim) and made them accessible on the internet so that the public may obtain a sense for the difficulties. See [9].

identical, still have strongly overlapping definitions in the two sciences[18], e.g.: What is a function, what is an object, what is a relation? The term *function* possesses extraordinary significance in this context. As a neurologist, Freud had a clear notion of the difference between *function* and *behavior*. Psychoanalysts without a natural scientific background, on the other hand, apparently do not understand this connection so readily.

Computer Technology and Psychoanalysis			
Computer technology	**Psychoanalysis**	**Commonality**	**Both reject**
Definitions			
datum	psychic energy	information	
class	drive	function	
category	defense	object	
metadatum	unconscious	relation	
composition	conscious	valuation	
Methods			
axiomatic	non-axiomatic	freud attempted an axiomatic approach	
		top-down approach	bottom-up approach
formal	not formal		
			statistical methods for development
		method of model generation	exclusively behavioral description
		validation	
		interoperability testing	

Table 3.1: Commonalities and differences between the two research areas

These commonalities, especially in regard to methods like the use of the term *function* by Freud or the top-down design approach, prompted the SiMA team to increasingly focus on psychoanalysis while ignoring other psychological schools of thought. The important terms from Table 3.1 will be

[18] Many millions of Euros are spent every year to establish so-called standardized terminology in technology: One need only think of the many standardization committees like ISO, CEN, DIN or ON staffed with high-ranking experts. It is important to bear in mind that these various committees often define and use the same terms differently, a fact the uninitiated are often not aware of. To synchronize all these definitions is impossible, and it would be pointless to sit butchers, chimney-sweeps and computer engineers around a single table to attempt to do so.

discussed in the following, but the crucial term interoperability testing shall be mentioned specifically beforehand.

To engineers, the term interoperability refers to the capability of different systems to work together. Testing means that this interoperability is appropriately validated or even verified through experiments of some kind.[19] In communication technology, which is based on information theory, this concept has obtained great significance due to the costs involved. A simple technological example is this: Two devices are referred to as interoperable if they can communicate with one another.

In psychology, the term interoperability can also be applied to different schools of thought: These schools are obviously generally not interoperable, as their theories at least partially contradict each other. Freud saw an interoperability between his first and second topographical model, however. In the following we will explain that the contradiction between the first and second topographical models can be eliminated through a minor definition modification when one applies the information theory of computer technology.

But what exactly is information theory?

Norbert Wiener, an American mathematician, is considered the founder of cybernetics and saw the field as a part of communications engineering and technology. One of his most influential works is *Cybernetics or Control and Communication in the Animal and the Machine* (1948). Among the people working in Wiener's environment was Claude Elwood Shannon, a mathematician and electrical engineer and who was likewise from the United States. Shannon is considered the founder of information theory, which is based primarily on probability theory. Its topic is the structural and quantitative registration and adaptation of data for the transmission, processing, and storing of the information encoded therein. Today, this theory is the basis for all technical information systems like telephones, computers and control systems of every kind.

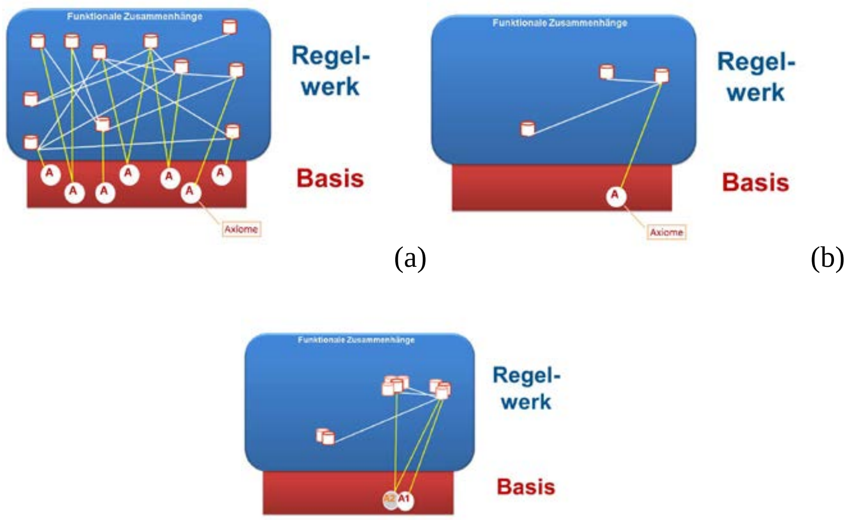
But with more than 60 years having passed since then, knowledge in information theory has increased greatly. There exists not one single self-contained field as was the case in Wiener's and Shannon's time, but many individual disciplines like communication technology, computer technology, informatics and their many sub-disciplines. The information theory of technology in our context refers to the set of theories dealing with the description of information systems. In information systems, large amounts of information are processed, stored and communicated. Data are the carriers of information, and become information through their meaning.

The following sections elucidate those information theories with particular significance for the SiMA project.

[19] The term provability is intentionally not used here, since engineers generally have a limited interest in proof. Proof is only pursued if it is financially profitable.

3.2 The Axiomatics of Bertrand Russel

Bertrand Russel is considered the founder of analytical philosophy; his essential book was *Principia Mathematica* (with A. N. Whitehead). He was designated to accept a professorship in New York in 1940, but was prevented from taking on the position by fundamental Christians who disagreed with his scientific and strictly analytical and factual discussion of terms like faith, morals and marriage. His concepts were based on the assumption that every construct of ideas, and therefore also that of religion, rests upon axioms from which a set of rules (propositions[20]) is deduced (Fig. 3.1 (a)).



(a) (b) (c)

Fig. 3.1: Axiomatic constructs of ideas: (a) axiomatic construct of ideas, (b) distinct correlation, (c) "fuzzy" correlation (A1: definition 1 of affect; A2: definition 2 of affect; A3: ...)

Axioms are the basic terms of a model which may not contradict one another. Examples from mathematics are equations of Boolean algebra (computer technology) like:

$1 \wedge 0 = 0$; with $\wedge$:= AND
$1 \vee 0 = 1$; with $\vee$:= OR

Examples from physics are basic definitions like the measures of length and time. Of course such definitions are subject to change in case of new findings. Russel explains that correspondingly, axioms cannot be proven but the rules derived from them, can. Rules can be deduced from other underlying rules in a process repeatable until one ultimately arrives at the unprovable axioms. Hence

[20] In order to preclude misunderstandings it should be mentioned that what we refer to as a *rule* in computer technology is called a *law* in formal logic. In logic, *rules* are elements of meta-language in contrast to axioms of object language – a differentiation Russel does not make.

every (!) rule must be deductible from axioms. Russel applies this train of thought to forms of government and society, to religions (a religion being a construct of ideas based on axioms that cannot be proven), to mathematics and every other kind of thought construct.

This principle works as long as the terms possess a distinct correlation (Fig. 3.1 (b)), meaning they do not contradict each other. It forms the basis for national and international technical standardization commissions into which industries and governments around the world invest huge sums of money (e.g. ISO, IEC, CEN, CENELEC, OVE, or DIN). All terms must be unambiguously defined, otherwise it would not be possible to build highly sophisticated aircraft, washing machines or buildings the way we do today.

Fig. 3.1 (c), on the other hand, shows the general approach of the humanities as seen from the perspective of engineering. Words are intentionally defined ambiguously in order to be able to use them differently in different contexts, with nuances of distinction – under the assumption that the described systems, processes or contexts are so *complex* that they cannot be precisely defined anyway, and that they have to be explained with shifting terminologies depending on perspective. This becomes visible in citations within scientific treatises, for instance: As certain terms are used differently depending on context, the respective authors must be quoted frequently to elucidate exactly how they meant what they said. This is not the case in engineering; instead, one makes reference to clearly defined equations and formulae, to standards and the terminology they employ.

Because Freud attempted to formulate his findings in well-defined natural scientific terms[21] – he considered himself a natural scientist for the most part[22] –, his models are comparatively practical for conversion into technical models. This does not apply to the work of most modern psychoanalysts who no longer follow a strictly Freudian orientation. Their writings are generally not axiomatically founded, thus making it much more difficult for engineers to implement their terminologies in a natural scientific fashion. Chapter 7.1 of this report will go into concrete detail on the axiomatics definitions of the SiMA project.

[21] "It is only after more thorough investigation of the field of observation that we are able to formulate its basic scientific concepts with increased precision, and progressively so to modify them that they become serviceable and consistent over a wide area. Then, indeed, the time may have come to confine them in definitions. The advance of knowledge, however, does not tolerate any rigidity even in definitions. Physics furnishes an excellent illustration of the way in which even 'basic concepts' that have been established in the form of definitions are constantly being altered in their content." Freud, S. (1915). Instincts and Their Vicissitudes. The Standard Edition of the Complete Psychological Works of Sigmund Freud, Volume XIV (1914-1916), p.116

[22] Freud initially attempted to explain psychic phenomena neurologically (biologically), but gave up on that notion as he was unable to find a reasonable model for the transition between the world of physics (neurology) and the psyche [Fre 15, p.273; Fre 35 (see quotes Q11 and Q12)]. This did not mean, however, that he abandoned the natural scientific method – as is occasionally interpreted today – of describing phenomena, developing models and explaining and validating phenomena through those models.

3.3 Functions – Data – Behavior

The computer engineering terms *function, datum* and *behavior* possess fundamental significance within the SiMA project for the conversion of the psychoanalytical models into models of natural science. More precisely, the terms *function* and *datum* stand vis-à-vis the term *behavior*: *Behavior* can be described in the shape of process sequences, i.e. mechanistically and physically. For example, an object moves in a certain distinct way. The behavior of objects can also be observed sensorially. But behavioral descriptions involve the grave disadvantage that they do not fully describe an object (system), but only its behavior under given basic conditions and in a given period of time. Therefore computer engineering introduced the term *function* to describe the structure of a unit or object. This point is addressed in [Die 12, p.127: freely translated]:

' .. At this point one must remember, as Leuzinger-Bohleber emphasizes in (Leuzinger-Bohleber 2008, p.34)[23] the widespread confusion of behavior with the underlying functions which cause that behavior …". The decisive step – and one of the great merits of Freud – is to derive a *functional* description from the *behavioral* description, a task which every student of computer engineering must undertake early on in his or her studies. For example, a customer requires a computer to control a process which has the *behavior* B_1. From this must be deduced the behavior B_2 that the computer must have in order to control the *behavior* B_1. From the *behaviors* B_1 and B_2, the computer engineer must finally deduce the *function* F_2 of the computer to be developed.

The research into *Braitenberg vehicles* (Braitenberg 2004)[24] focuses on the difference between the *functions* of a system and its *behavior* with regard to the respective scope of possibilities for description. With simple experiments using autonomous artificial agents (=vehicles), Braitenberg shows what it means to describe their respective *functions* and *behavior*. The *functional* description becomes progressively simpler (relatively to the *behavioral* description) than the *behavioral* description the more complicated the system is. For a highly complicated system, it becomes nigh on impossible to describe the behavior although the functional description may still be quite simple. Thus a functional description, in contrast to the corresponding behavioral description, is generally less complicated[25]. The road from the behavioral to the functional description, however, can become infinitely complicated[26]. The development (i.e. the synthesis) of a computer is based fundamentally on a functional description; this is what allows the machine to be realized. A computer engineer cannot *build* anything with only a behavioral description. What is more, completeness of a behavioral description is difficult to achieve without a functional description, and even more difficult to prove. But this

[23] [Leu 08, p. 34]

[24] [Bra 04.1]

[25] Braitenberg explains this using the example of an imaginary vehicle consisting of two wheels and two light sensors, each directly controlling the motor for one of the two wheels. The more light falls onto one of the sensors, the faster the respective wheel will turn. The sensors can be placed in different positions on the vehicle. If a sensor mounted on the left side of the vehicle controls the left-hand wheel, and a sensor mounted on the right of the vehicle controls the right-hand wheel, then the vehicle will move away from any single light source. If one switches the positions of the two sensors, the vehicle will move toward the light source. Braitenberg then introduces four and more sensors to the system and proves that the vehicle can be made to move (for instance) in a figure 8. When the number of sensors increases, the functional description of where the motors are located and how strongly they affect the motors becomes slightly more complicated, while the behavior of the vehicle becomes vastly more unpredictable.

[26] The authors see the particular and ingenious achievement of Freud in his ability to deduce the functions of the psyche from the behavior of his clients.

completeness is a necessary requirement to be able to build a computer or develop a simulation program (e.g. of the human psychic apparatus) – the ultimate goal of the SiMA project.'

This illustrates clearly that to achieve a model of the brain, it will be necessary to develop a *functional* description of the information process of the psyche. Sigmund Freud recognized this: In his second topographical model of the psyche, he identified *entities*, i.e. *functions*, and (rightfully) refused to commit himself to a fixed notion of what constituted them, i.e. what kind of hardware or other type of mechanism he did not understand. Thus he made an ingenious decision, and the right one, by resorting to a higher level of abstraction where it seemed to him to be easier to describe his model of the psyche. He viewed it as a set of (*functional) entities*, which today is the commonplace approach of computer engineering. Before a machine is developed, it is described *functionally* – and following this abstract *functional* description, one decides which of the *functions* to implement as hardware and which as software, which as separate components and which as virtual, distributed components within the system.

A further aspect now comes into play which Freud was naturally unaware of in his time. Once the *functional* description of a model is finished, it is possible to feed it with *data*, e.g. in a simulation, and test the *behavior* it displays under predefined basic conditions. Hence the *data* describe the dynamic *behavior* of the *entities*. The basic conditions can be varied arbitrarily and the model's correspondence to the desired specifications validated via its displayed *behavior*.

Therefore the *data* represent the values to describe the *behavior* of a model. In terms of philosophy of science, this means that one describes a physical object by differentiating it into *functions* and *data*. Or to put it more graphically: By tearing it apart into *functions* and *data*, which of course is impossible in the actual physical sense, but necessary for understanding from the point of view of information theory.

This approach is a principle applied in information technology in order to control it, but it also means a departure from mechanistic thinking. A different principle is that of the *layered model*.

3.4 The Finite-State Machine Model

The Mealy Machine represents an essential basis for calculating digital circuits in the realm of digital engineering. It is thus a fundamental tool of computer engineering. For reasons of scope, it is impossible to go into details of its functionality, just as it was for the Braitenberg vehicles mentioned above. To understand how calculations can be performed using the Mealy Machine, the reader is encouraged to refer to [Wen 74]. The underlying principle however is pivotal for the understanding of SiMA itself and thus noteworthy enough for the authors to consider it necessary to explain it at least briefly here. This may also help to understand that *complex* systems like the brain cannot be comprehended in information theory without the layered model. The Mealy principle furthermore elucidates how difficult it can be to depart from the physical world and enter the realm of information theory, whose thinking is in part completely different. It is very dangerous, for instance, to use examples from the physical world to explain circumstances in information theory. This is illustrated by the term psychic energy – an established term in psychoanalysis which represents something completely wrong in the physical sense. Some psychoanalysts even describe it as flowing like water; this leads to explanations that contradict each other, for flowing water would imply flowing energy. But no energy can be transmitted through neurons. Similarly, physical matter implies that time represents a physical variable – but time has no place in information theory.[27] Psychic energy simply has nothing at all to do with the physical concept of energy, but instead is a measure for the valuation of perceptions, decisions, things, words etc. In order to explain this awkward issue, the way of thinking of information theory must be at least rudimentarily illuminated. The intent is to show that information theory can only be understood – from the point of view of today – by use of thought constructs like the finite-state machine model. We will however refrain from introducing further thought constructs of such type in this treatise.

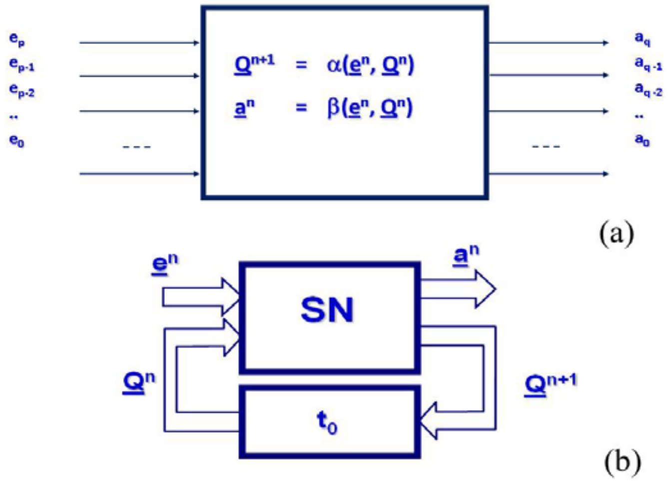


Fig. 3.2: Mealy Machine (a) represented as input/output system with internal states, (b) differentiated representation showing combinatorial circuit CC (pure logic) and physical part in which time is accounted for *$\underline{e}^n$: input vector, $\underline{a}^n$: output vector, $\underline{Q}^n$: current state vector, $\underline{Q}^{n+1}$: future state vector*

Fig. 3.2 (a) shows the Mealy Machine as an input/output functional unit. It is defined by the input values at the input interface, the output values at the output interface and the internal state values. Fig. 3.2 (b) shows the differentiated machine diagram. The upper box in Fig. 3.2 (b) represents the logical function in which the relations between the logical elements are described, while in the lower box, physical parameters like time are factored in and hence described in a physical sense. Thus in this second image, physics is torn into two parts, the realm of information theory where time plays no part, and the realm of physical relations, where there is no logic. These two worlds are connected via the Q vectors (state vectors).

What is the basic idea? What is the bridge for our understanding? By introducing two abstracted layers, two phenomena are decoupled: The purely physical and the information-based phenomenon. This also means that two radical abstraction processes are separated. The first abstraction, defined by the lower layer, is described through the "information-free" physical laws, and is therefore referred

[27] In this context, psychoanalysts should bear in mind the primary process in which temporal sequences can proceed quickly or very slowly.

to as the physical layer. The upper layer describes the digital logic, with the variable time being excluded.

One must nevertheless always keep in mind that both layers are ultimately one and the same, namely physics. The two different phenomena are merely being described in two different layers from different perspectives. The interfaces between the layers must be unambiguously (axiomatically) defined.

Based on this principle, all digital circuits can be calculated and therefore defined. Hence the machine model is the premise for the layered model to be explained in the following. This layered model in turn is the prerequisite for a differentiated view, and thus description, of the nervous system and the brain.

3.5 The Layered Model

The finite-state machine model (like the Mealy Machine) from computer engineering can be expanded to include further abstraction layers in its upper layer, the logical layer. This is how one can visualize the development of the 7-layered ISO/OSI model [Die 98], whose bottommost layer again features the description of physical interrelations, with the higher layers defining various tasks necessary for the communication between individual models (machines). In this sense, the 7-layered ISO/OSI model can be viewed as an expansion of the finite-state machine model, and in fact should be regarded as a template (recommendation) for the development of new communication protocols between computer units.

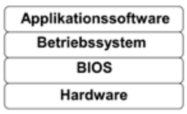


Fig. 3.3: Possible layered model of a computer

The layered model is also applied in computer engineering as a tool for describing the structure and connections of software. The various software entities of a computer are assigned to different specific, functionally defined layers. Fig. 3.3 provides a simplified example; it shows a model for a PC with three software layers. Software is a form of description for the respective information system. The software forming the connection with the hardware is the BIOS (basic input/output system). Situated above it is the operating system, which employs the BIOS to access the hardware components. Above this are applications like Microsoft Word or Excel. Connections between software functions in different layers can only be established efficiently if the two layers are directly adjacent. It would not make any sense to explain a function of the word processing software MS Word, which is located in the *application software* layer, on the basis of transistors – for the latter are described in the bottommost layer *hardware*. The program MS Word can only be brought into relation with the program in the layer below it, namely the operating system.

Two fundamental laws of the ISO/OSI model, which are formulated in its standard definition, also apply to the functional layered model of a computer:

(1) The contents of the layers can be changed so long as their functionality and performance are not compromised; this means that the interface definitions between the functional layers may not be altered if the layers are modified. For example, whether the hardware is constructed on the basis of logical circuits or a different technology like neuronal networks has nothing to do with the other layers.

(2) How the functions within the layers are specified in detail is up to the developer. They can be described in the form of software or in the form of hardware (both are ultimately physics, only in two different ways of description).

There is no alternative to the layered model for the description of *complex* information systems in computer engineering. It is the only tool for their characterization, and must be used by default if a *complex* overall model is to be described. Naturally, other tools have to be applied during this procedure as well.

From this it can be deduced that there is currently likewise no alternative to describing the neuronal system, which includes the brain and represents a *complex* information system of extraordinary dimensions, in terms of a layered model. It is interesting to note that the neurologist and psychiatrist Alexander Lurija [Lur 01] came to this realization very early on – and of course completely independently of the preceding statements about information theory – and accordingly developed a three-layered model of the neuronal system. His design cannot be presented in detail within this report, however. In Lurija's layered model, functions and topological relations, which according to the natural scientific principles of the ISO/OSI model must be strictly differentiated because they are in fact located in separate layers, are intermixed. Topological aspects must in general be assigned to the bottommost layer 1. These inconsistencies in Lurija's model were rectified in the SiMA model's development process.[28]

3.6 Control Systems, Statistical Methods and Behavior

Multiple control loops are active within the human body (Fig. 3.4 (a)), physiological ones as well as psychic ones. These include the control system for the adjustment of homeostasis, the nervous reflex arcs, and purely psychic control mechanisms like the pleasure-unpleasure principle which will be discussed in detail later.

The behavior of a control loop can be relatively stable, but it can also display great instability (Fig. 3.4 (b)). This is caused by the respective control parameters. Multiple control loops, i.e. several loops which regulate each other, are especially difficult to handle since even small changes to a single loop can have massive consequences for the others. If one views the neuronal system as a layered model as described above, one must visualize it as containing several control loops interconnected with each other (Fig. 3.5).

[28] One must bear in mind that Luria established his theories and models long before the introduction of information theory of computer engineering. It is hence all the more remarkable that he developed the *layered model*.

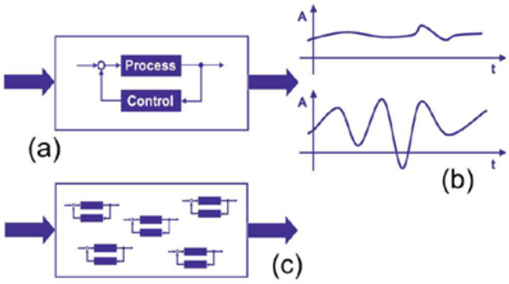


Fig. 3.4: Control loop principle
(a) Simple control loop; (b) stable and instable behavior; (c) multiple control loops

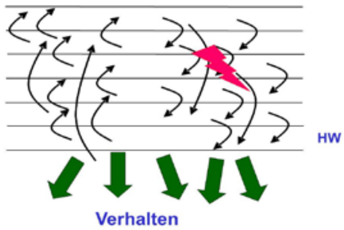


Fig. 3.5: Control loop principle of the neuronal systems illustrated in the layered model
HW: hardware

Once again, the hardware is described in the bottommost layer forming the sensory and operational connection to the outside world; i.e. all behavior is displayed via the hardware layer.

Assuming that a disturbance occurs for whatever reason in one of the layers (Fig. 3.5, red lightning bolt), various control loops will obviously react to it. One loop might be capable of eliminating the disturbance, but by doing so may simultaneously place another loop in a state leading to further perturbations which are not directly related to the original interference.[29] These connections can only be determined if one possesses a model of the different functional layers. What does this mean? Disturbances are not explicable in a multi-layered model - like the mental apparatus - if one records the behavior exclusively using statistical methods in the bottommost layer (hardware layer). Changes in a human being's behavior need not necessarily be related directly to a occurring disturbance, but may in fact originate from control loops reacting to that disturbance. Hence statistical correlations can be correctly interpreted only by experts, and only if a *robust*[30] *model* exists.

Artificial intelligence and the field of natural science-oriented cognitive science have their foundations in behavior-based, psychological findings of psychology or pedagogics which are generally the result of empirical research. Empirical research commonly employs statistical methods which, as explained in Chapter 3.6, can be used to determine possible dependencies but are not of great use for establishing functional correlations. Behavior-based statements by psychologists on the mental apparatus are thus of no help to engineers. The copy of the behavior says nothing about the

[29] A well-known example are the side effects and interactions of various prescription drugs and other medication.

[30] The term *robust model* should be understood to mean that the model can be applied to the simulation of various arbitrary (but realistic) use cases, and not just a select few defined cases.

actual functionality in the various layers. Engineers require a functional (layered) model (and not a description of behavior) developed by appropriate experts. Placed in a simulation, this model can then be examined using statistical (empirical) methods; if it does not produce the expected behavior, it must be adapted by the experts on the mental apparatus. The resulting new behavior can once again be examined, etc. This represents a reasonable, scientific and iterative approach to establishing a robust model.

This statement is crucial, for only psychoanalysis can provide a model of the mental apparatus. It is the only discipline to describe a *complete*[31] functional model and its behavior without statistical methods. The various other schools of thinking only cover certain partial aspects which overtax the engineer due to his lack of appropriate learning.

And this fact is of pivotal importance: it is for this reason that the SiMA project makes sure that psychoanalysts are part of its team so as to evaluate all psychological statements for the model professionally and in cooperation with the engineers. It would be ideal in natural scientific terms if psychologists were to examine the model using their statistical methods after its development, which would represent an evaluation of the psychoanalytical model and the psychological methods.

3.7 Incorrect and Obsolete Models

It is obvious that an incorrect model can lead to unusable results. However, it is often a long and difficult path to determine the correct model, as the following example illustrates: Before Copernicus, European scientists were certain – because they were able to observe it "without a doubt" every day – that the sun revolved around the earth (see below, bottom right image in Fig. 3.6). Nobody doubted this, but it posed severe problems for astronomers since all orbital calculations they developed could not provide the accuracy they hoped for. Eventually they came up with the complicate model of epicycles (see below, center image in Fig. 3.6).

But even then, the results of the calculated paths of celestial objects deviated too much from reality. The contradiction seemed unresolvable for the Church and philosophers of the time, until Copernicus did something unheard of by placing the sun at the center of the universe. In doing so he angered the Catholic clergy and many philosophers as well, for he imperiled their world view by contradicting the behavior they observed in the sun. But with this alteration to the model, the stars suddenly followed simple elliptical paths, and the observed paths conformed to calculable expectations.

[31] The term *complete* should be taken to mean a model of the mental apparatus featuring all integrated layers and all functions of layers 1-3 in level 1 (see chapter 5, fig. 5.13), but not necessarily that all these functions and sub-functions are integrated in detail or even that all images, motions and other memories are implemented . The desire to integrate the entire history of a human being is not imaginable. It is therefore obvious that the desire to copy a concrete human being in a robot is an illusion.

The path from observable *behavior* to a correct *functional model* can be very difficult indeed [Bra 04.1], but is nevertheless a requirement for the ability to accurately interpret the *behavior*[32]. A correct and complete model is needed, which is the reason why many psychological schools of thought were analyzed during the SiMA project, and why ultimately only psychoanalysis was able to bear up under our natural scientific criteria. Every engineer must be aware that many iteration steps are necessary before a conclusive model is achieved; he must also be aware that every model represents an abstraction and must therefore undergo verification, having to be modified or possibly even discarded as a result of improved measurement and testing procedures or new findings. By definition, models cannot be definitive and have always been subject to evolution throughout history.

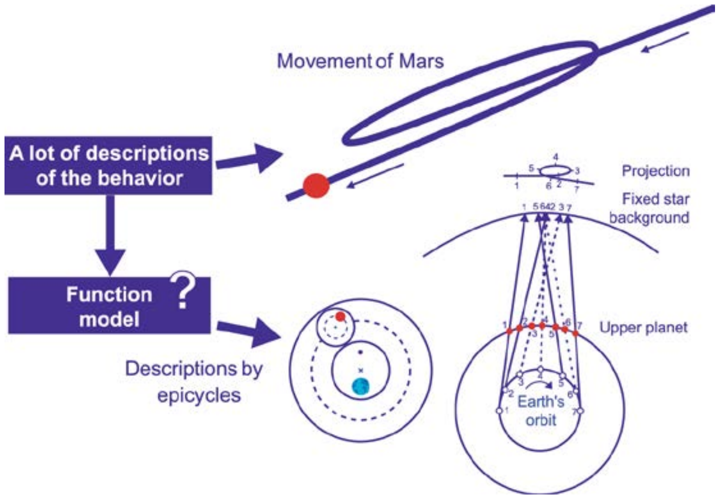


Fig. 3.6: Calculation methods for the orbit of Mars

3.8 Interoperability and Artificial Intelligence

Psychotherapeutic schools view it as their fundamental task to help humans who suffer from psychic afflictions. Different concepts of the behavior and functioning of humans, more precisely of the *process* of man, led to different *schools* of thought with different underlying theories and therapeutic methods. Together with the various schools, different associations were also formed which support the respective schools of thought institutionally.

It is interesting to note that none of these schools, nor even psychology in general, have developed holistic models of the human information system – with the exception of those schools which are based on the psychoanalytical theories of Sigmund Freud (Freudians, Kleinians, Lacanians, …). But

[32] Dietmar Dietrich (the initiator and principal of the SiMA project) saw his central task as Professor of Computer Technology in explaining to his students of the field Digital Chip Design the various methods of deducing the *functions* of an electronic chip from the description of the associated process *behavior*.

even these schools have been unable to achieve a unified model, as illustrated by the upper part of Fig. 3.7. Furthermore, even some of Freud's own statements, e.g. those concerning the first and second topographical model, cannot be brought into correlation (i.e. made interoperable) – which up until now has represented an insurmountable problem. But the goal of natural science and its fundamental challenge is to generate and formulate consistent and unified models, and a simulation of the brain will be possible only if such a consistent and unified model is developed. The example of the first and second topographical models, which have been successfully consolidated during the course of the SiMA project, shows that this is possible. That the physics and functions of nature do not contradict each other cannot be proven, but the physical and information-theoretical experiments of computer engineering with their underlying unambiguous, contradiction-free functional models show that it is the case.

The topic in its entirety cannot be discussed in detail in this context; abridged explanations providing the decisive information needed to understand the connections will have to suffice. For better comprehensibility, this will be done once in regard to artificial intelligence and once from the perspective of psychoanalysis.

3.8.1 Interoperability in Artificial Intelligence

From the contradiction between the two topographical models of psychoanalysis, one might be inclined to infer that psychoanalysis is self-contradictory by definition. In any case, it is safe to say that psychoanalysts have learned to live with contradictions.

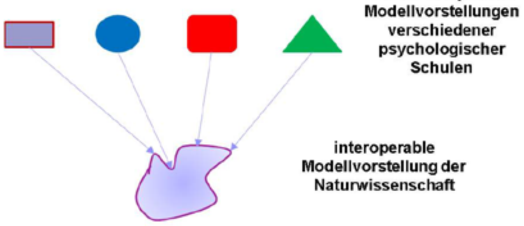


Fig. 3.7: Discrepancy in finding an interoperable model concept

The way of thinking of computer engineers is completely different: the computer engineer as a natural scientist wants to be able to describe the processes in nature functionally and without contradictions in order to understand them.[33] If he wishes to integrate bionic principles into such

[33] It is important to emphasize that the measured *data* describing the *behavior* of the *functions* not only can contradict each other in practice, but will be inaccurate as a matter of principle. The *functions* of the psyche are quite probably identical in all humans. However, the psyche consists of *functions* and *data*. Since parametrization and especially knowledge content, i.e. the *data*, can be different, contradictory and constantly changing in every human being, *behavior* in humans can never be verified nor tested in repeatable experiments. The principle of the validation of model theories must therefore be

descriptions, he requires models that must not be self-contradicting. Until now, artificial intelligence has only attempted to imitate certain capabilities and properties of humans[34]: how they walk, how they perceive objects optically, their body schema, etc. In natural science, and in particular in engineering, the utmost care is taken to not let models for one phenomenon contradict models for other phenomena. Technical models must be developed in an interoperable fashion, as suggested in Fig. 3.7: the various models must be consolidated into a single interoperable model. But what of the psychological models which the deliberations of artificial intelligence are based on? Are they truly interoperable? Are the underlying psychological findings (scientific publications by the various psychotherapeutic schools of thought and different psychological observations) tested for interoperability?

As a computer engineer, reading in [Bre 02] how the results of various psychoanalytical schools are combined without testing them for interoperability leaves one in a state of wonderment. Naturally, this verification for interoperability cannot be accomplished by engineers, but only by the appropriate (psychoanalytically trained) experts – just like the average peasant in the 15th century was unable to verify which model for the movement of the stars was correct, or what contradictions between the different models arose. Engineers are similarly overburdened with the validation of the results of the various psychoanalytical schools, and are thus unable to simply accept them as is the case in [Bre 02]. During the adoption of psychoanalytical findings, it is important to make certain that – on the psychoanalytical as well as the technical side – only such findings are taken into consideration which are interoperable with one another and will therefore result in an interoperable model. This can only be achieved by adhering to two basic principles: Firstly, a fully axiomatic terminology must be applied, without which computer engineering cannot operate. Secondly, the psychoanalytical experts must likewise ensure an interoperable model description. This is difficult since the methodological approach in psychoanalysis was hitherto different from that in natural science. For example, if the term affect is explained in different ways depending on certain influences, then interoperability is at best impeded – and at worst nonexistent.

There exists a further problem as well: If the terms feeling and emotion represent nearly the same thing, appear in the primary as well as the secondary process, and are subject to different phenomena while at the same time inducing different phenomena, with every explanation making reference to the definitions of Freud from which not even the slightest deviation is possible, then from the point of view of natural science there is no potential for movement in regard to the differentiation and expansion of terminology. Natural science, however, lives from the fact that certain terms or phenomena must be examined more closely from time to time and, if required, two or three new terms are developed as a result, thus describing the original concept with more differentiation or precision. Sometimes this process can even result in the original term being abandoned entirely or at

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reconsidered, a process occurring within the SiMA project. The SiMA team is aware that many natural scientists are quite critical in regard to this statement.

[34] To model the brain in a layered model using top-down design following the approach of computer engineering was attempted for the first time by Dietrich in [Die 00].

least clearly delimited from the newly developed terms.[35] From an engineering point of view, this is something that is lacking in modern psychoanalytical research.

3.8.2 Interoperability in Psychoanalysis

The efforts for interoperability in psychoanalysis are currently focused exclusively on its application in diagnostics, therapeutic practice and intervision. An example of this is the development of *operationalized psychodynamic diagnostics** (OPD) in the areas of diagnostics and treatment. The work of Otto Kernberg and Gert Rudolf, which forms the basis for these models of interoperability [Ker 00, Rud 02, OPD 06], focuses not on the metapsychological functions developed by Freud, but instead replaces them with personality characteristics whose composition as seen from a clinical-psychoanalytical operationalized perspective allows a concrete structural pathology diagnosis. Based on this structural diagnosis, therapy is provided following concrete focal points which appear to be most effective according to clinical experience and statistical evaluation.

Another product of contemporary efforts for interoperability in psychoanalysis are the so-called "Tuckett frames" developed by David Tuckett et al. as a method for comparing clinical experience in the area of psychoanalytical treatment [Tuc 08]. This system is likewise not concerned with interoperability in the description of metapsychological functions of the psychic apparatus, but instead on the way in which psychoanalysts speak about their work and experience the effects and interdependencies in their analytical practice. The goal of these consistent "frames" is to provide analysts with a joint interoperable basis in order to allow them to find common ground across the various schools and their terminologies in intervision groups, i.e. in the description of the progress of psychoanalytical treatment.

In both cases, OPD as well as Tuckett frames, the efforts towards interoperability are not explicitly related to the metapsychological and theoretical establishment of high-resolution descriptions of the functions of the psychic apparatus. These prominent examples of contemporary attempts to promote interoperability in psychoanalysis instead concentrate on harmonization of the diagnostic view of the patient's behavior (OPD) or supervisorial dialog about the perception of the analyst (Tuckett frames).

Hence these current-day projects aiming at increasing interoperability can provide no contribution to the development of a simulation of the psychic apparatus based on natural scientific modeling, for compared to the SiMA model of the psychic apparatus they employ a relatively small number of descriptive elements interdependencies.

[35] This process is the hardest part of the work on the SiMA project, requiring the most effort but eventually resulting in the axiomatic definition of all terms in SiMA. It was only possible to undertake this task professionally because some of the technical project leaders in SiMA have accumulated great experience in national and especially in international standardization commissions which invest great effort into the definition of consistent terminology and clear axiomatics.

The SiMA project on the other hand recognizes – as has been explained above – that development of the psychoanalytical model is impossible without axiomatic definitions. For this reason, much time is being invested into such an axiomatic framework (see Appendix A).

3.9 Projection

Chapter 3.3 (*Functions – Data – Behavior*) makes the distinction between functional model and behavior, using this abstraction to achieve a better understanding of the process of the mental apparatus. When one analyzes projects for machines like CB2 [10] (Fig. 3.8), however, one must introduce a further term from artificial intelligence: projection.

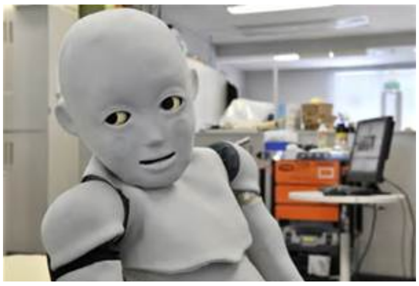

Fig. 3.8: CB2, Japanese robot child

Machines like CB2 may be called robots, but the original term “robot” refers to *human-like* machines, that is machines whose behavior is similar to that of humans (see also [Bru 12, p.67, footnote 8]). If one reduces this to the movements of machines or their mere outer appearance, then every puppet could be classified as a robot. More likely, however, one would associate the term human-like with feelings, with conscious and unconscious behavior. But feelings in machines do not exist as yet; thus human-like robots are currently nothing but wishful thinking, with everything else being projection. Small children project their concept of life, i.e. something human-like, onto a puppet, and some grown-ups project similarly onto machines like CB2. But CB2 is “only” a highly complicate machine with many internal computers and control loops. Its outer appearance or its movements do not make it human-like.

3.10 Interdisciplinary Discourse

The quality of a scientific treatise is judged among other things by the degree to which the researcher takes into consideration and discusses pertinent scientific literature. This represents one of the pillars of science. Hence if modern AI research uses terms like feelings or emotions (e.g. in the field of emotion-based AI), then it should take into account the scientific findings of various disciplines and experts, including those of psychoanalysis. No serious efforts have hitherto been made by AI research projects in this regard, however. This disregard of psychoanalysis is not only a sign of ignorant behavior, but can rightfully be identified as unscientific.[36]

3.11 Resolution of the Contradiction Between the First and Second Topographical Models of Psychoanalysis

The following observations assume an essential aspect: That the first and second topographical models must be viewed from a new perspective. Psychoanalysis to this day accepts that there are inherent contradictions in this area, i.e. that the first and second topographical models may contradict each other. From the perspective of natural science, however, it means there exists an issue that requires further examination, for technically speaking such terminological contradictions must be eliminated in order for simulation to be possible. Where, then, is the discrepancy located?

Technical information theory distinguishes between *functions* and *data*. For illustration, let us examine a technical device of computer engineering like a modern temperature controller which factors in weather *data* from the internet. The temperature controller has *data* inputs and *data* outputs. Naturally, the *functional* elements operating inside it may not exhibit any contradictions, since otherwise it would not work. Particularly over the internet, however, it is possible for contradicting weather *data* to enter the controller, since the internet is a relatively *complex* information system. Such contradicting *data* may not cause the controller to go haywire – instead it must make appropriate decisions, e.g. request newer, more plausible *data* or filter out the implausible *data*.

Engineering, and natural science in general, can thus live quite easily with contradictions, as long as one is aware of where they occur: They cannot be avoided in regard to *data*, but must be avoided pertaining to the definition of *functional* units. Hence when we speak of contradictions in the mental apparatus, this is to be considered normal from the point of view of computer engineering and information theory. Information theory is accustomed to working with contradicting *data*, and knows that this requires certain methods not needed in other areas.

If one views the second topographical model as a pure functional model without any *data* contents, then it must be defined without internal contradictions. And if one views the first topographical model as a *data* model (as opposed to a *functional* model) in which the attributes of the data are defined, e.g. whether they are conscious or unconscious, then no contradictions between the two topographical models arise. However, one must then also stop using the terms “the conscious” and “the unconscious”, since it is the *data* (i.e. the attributes of the *data*) that are conscious or

[36] The methodological state of psychoanalysis is controversial. Popper [Pop 63, p.48-57] considers it unqualified, Stegmüller does not [Ste 86, p. 413-432; Dob 15]. Uncontested is the fact that the psychoanalytical models of the psyche have proved themselves in the practice of clinical application, and that this fact is empirically substantiated [San 01, p.277-310]; furthermore, that these models have in recent years once again begun to attract interest from natural sciences like neurology [Sol 04].

unconscious, and they are manipulated and stored in the *functional* units *id*, *ego* and *super-ego* and transferred between them. "The conscious" and "the unconscious" are not *functional* units or parts of *functional* units of the id, ego and super-ego, but attributes of the data[37].

Therefore, the terms "the conscious" and "the unconscious" are no longer used within the SiMA project.

3.12 Bionics – Engineering Based on Biological Principles

The term *bionics* indicates the intent to use phenomena occurring in nature for engineering. When using *bionics* as a search term in Wikipedia – and likewise when reading general literature on *bionics* [Rüt 09, Nac 02] – one finds that mostly physical, chemical, biochemical and similar phenomena are described, but rarely phenomena of nervous information systems. And this although precisely these phenomena are important for computer engineering, informatics, automation technology, etc. The SiMA project is located in the field of bionics, and proves beyond a doubt that dealing with the psychoanalytical model of the psyche and social aspects of humanity is worth the while of computer engineering for two concrete reasons. Firstly, phenomena can be discovered which have been laboriously developed in computer engineering although they could easily have been adapted from nature itself. And secondly, further phenomena can be discovered which are presumably suited to be adapted in engineering. An example for the first point would be the smart car. Until recently, motor vehicles had steering shafts and mechanical transmissions, whereas nature uses nervous signals to control e.g. the individual legs in insects – a principle which is currently being introduced in automotive engineering with the help of fieldbus systems [Diet 98]. Hence the introduction of the field bus could have been predicted many years ago if this particular area of bionics had been analyzed earlier for automation purposes. In regard to the second point, one need only think of decision units with a high level of abstraction, for which effective and truly useful technological solutions still do not exist to this day. SiMA shows that such decision units become possible if the information principles in humans could at last be better understood, and our project is on an excellent path to achieving this goal. We remind the reader of the EU project for the monitoring of the Krakow airport [Bru 07], which integrated results from SiMA.

[37] This also axiomatically arranges the three terms *functions*, *data*, and *behavior* relative to one another. The *functions* explain how a system is constructed, and the *data* are the carrier of information. *Functions* manipulate, store and transfer data, and the *behavior* of an object shows its current activity/dynamics. Hence *behavior* is determined by the *functions* and *data*.

3.13 Differences in the Way of Thinking Between Engineers and Psychoanalysts[38]

What is the fundamental difference between the way of thinking of engineers and that of psychoanalysts today? What knowledge in terms of information theory do engineers have nowadays which Freud lacked, and which psychoanalysts (knowingly or unknowingly) ignore? Where do contradictions appear in engineering science, and which of these contradictions must be accepted by engineers in a natural scientific context?

These questions beg answers from information theoreticians, and the response provided by the SiMA project is as follows: The information theoretician has learned to differentiate between (*functional*) *units* (*entities*), *instances, data,* and *tools*. These terms are not used in any definitive form in psychoanalysis; Freud was not aware of their differentiation. For the computer engineer, however, they are a part of basic knowledge. A *unit* is the model from which an *instance* results; this *instance* can then *function* dynamically. Let us use the *functional* unit of the software-based algebraic adder as an example. Such a software adder is formulated in a description language like C++, and its task is to add data. For the addition to be performed in the microprocessor, an instance is created during the dynamic process. Depending on the program, several instances may exist at the same time, with each having the same task of adding different values. In order to be able to construct or modify the adder in practice, and to test or manipulate the *data*, software *tools* are needed. Among these are the programming language C++ as well as appropriate testing, integration and analysis *tools*.

What in this concept can be contradictory? Only the *data* can; in fact, *data* are often contradictory. The *data* coming in on channel A can contradict those coming in on channel B. The engineer learns to accept this. It is his job. What is more, the natural laws are in no way violated by these contradicting *data*.[39]

The next question arising is this: How can the abovementioned differentiation be applied to the psychoanalytical models? What does this differentiation have to do with psychoanalysis?

Freud was unaware of this differentiation between *functions* and *data*/*information*. He spoke of the *ego* or *id*, but also of “the conscious” and “the unconscious”. But if the second topographical model is clearly and consistently defined as a *functional* model of *units* (the *id*, the *ego* and the *super-ego*) with many sub-units (like the definition of a software adder), then we must ponder which elements are not to be counted among the *functional units*? It is of course the *data*; these *data* (*images*, *motions*, *scenarios* – in short, everything that enters the *id*, *ego* and *super-ego*, is manipulated there

[38] The corresponding questions have been asked again and again, directly or indirectly, during workshops and conferences and will therefore be discussed here.

[39] And precisely therein lies the enormous difficulty for many psychoanalysts because they do not differentiate between data/information and the functions, seeing only an undifferentiated “whole”, i.e. the psychic apparatus including all its contents. This must invariably lead to contradictions, for the psyche contains contradictory data.

and exits the system) can be assigned attributes denoting whether they are *unconscious*, *conscious* or *preconscious*. They are assigned these attributes in the appropriate *functional* sub-units of the *id*, *ego* and *super-ego*. When this train of thought is followed consistently, the presumed contradictions between the first and second topographical model resolve themselves, for “the unconscious” or “the conscious” no longer exist as objects. There are only *conscious* and *unconscious* data (pieces of information). This also means that in the short term[40] it is not the *id*, *ego* and *super-ego* that are changing, but only their contents, i.e. the *data*. That these *data* are capable of altering the structure of the *functional* units in the long term is equally not surprising for the engineer – modern computers (embedded systems) also allow this behavior.

In this context, *transference* and *counter-transference* are tools of the *instances* for obtaining appropriate *data* which can then be checked and manipulated in the own instance.

What does this mean? It means that apparent contradictions in psychoanalysis do not speak against its natural scientific character at all, but instead become quite logical and understandable under closer scrutiny. On the other hand, it also means that psychoanalysts as scientists must learn to differentiate between *functional* units, i.e. *entities*, and their *data* (contents), and continue Freud’s work in order to define – in a first step – a consistent set of axioms in the sense of technical information theory. Naturally, all scientific findings since Freud will have to be integrated in this process.

We in the SiMA project have not investigated this process yet, but we are convinced that it is the path to bringing other psychological concepts and schools of thinking like object relation theory or) Lacaninan psychoanalysis into seamless connection with the first and second topographical model.

Under inclusion of technical information theory we thus discover new perspectives and find nothing precluding the modeling and thus simulation of the human mental apparatus. If Antonio Damasio in his book “I Feel, Therefore I Am” [Dam 01], or Mark Solms in “The Brain and the Inner World” [Sol 02; Sol 04], postulate that the brain can be analyzed with the means of natural science, then this can only be understood by us engineers as a challenge to ultimately simulate it.

3.14 Fundamental Model Concept of SiMA

Before the SiMA model is presented in detail, we must elucidate the fundamental concept underlying the model. It should be mentioned that this complete description was originally published in [Die 08].

According to [Die 04.2, Pra 06], humans collect visual information from the outside not like a camera, but instead already after only a scant few neuronal layers “see” only characteristic parameters like edges, circles, certain colored surfaces and contrasts [Foe 93, p.44]. The same applies analogously to the other senses like the sense of smell or the tactile sense. As per Fig. 3.9,

[40] The functions and sub-functions change their structure over the long term.

this means that a human only sees certain eye shapes, the position of the head or the posture of the body of the musician he is listening to, just as he or she only hears certain characteristic sounds, and associates (or *calculates*, in computer terms) the remainder of the image and the music from his huge *database* of previously obtained knowledge. In it, the *images* created in the past are stored; they are later recalculated into new images using new incoming *data* and can be put in long-term storage under certain circumstances [Vel 08]. According to [Sol 04] and [Pal 08], once *data* are stored they are never forgotten except as a result of destruction of the respective synapses or traumatic experiences. The second principle states that these *images* can be combined into sequences, so-called *motions* (see Fig. 3.10) [Pal 08], a process which occurs on the basis of symbolization. Such *motions* are very short, however, lasting only a few seconds at most [Pra 06]. In order to perceive, store or plan longer sequences, referred to as *acts* in SiMA, far more than this simple symbolized information processing is required according to [Sol 04, Dam 01]. This will be discussed in more detail in the following.

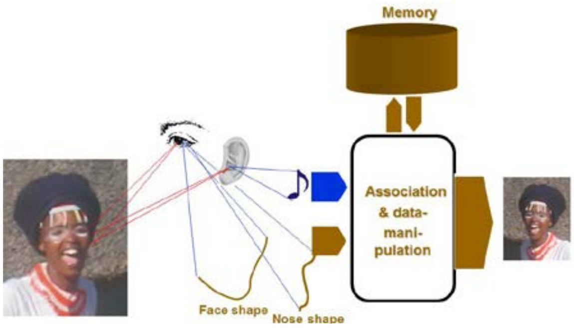

Fig. 3.9: Perception of the outer world, mostly via the internal database

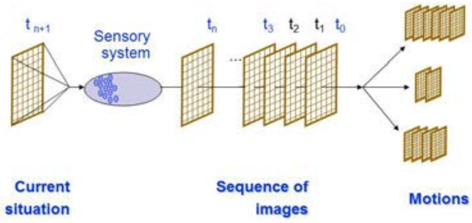

Fig. 3.10: Creation of images and motions

The third decisive aspect discovered by psychologists, pedagogues and psychoanalysts long before AI researchers is this: In order to achieve consciousness, humans need their body as well as representations of their body and the world. They perceive their body as part of the *outside world*, whereby the *outside world* should be understood in its separateness from the mental realm and is differentiated into an outside world inside the body and an outside world outside the body. According to the models of psychologists, pedagogues and psychoanalysts, the inner world is the image of the self[41] and the world which the human being develops over the course of its life and which consists of the symbolic representation of the outside world and the appropriate valuations. It

[41] The topic of the *self* was a separate subproject. See [Dob 15.1; Dob 15.2].

is not to be considered rigid; instead it is subject to continuous modification since it is valuated with feelings and continually evokes different associations. A human's notions of their own person and its environment are thus constantly being adapted. Old states can never be returned to; the images are constantly in fluctuation, they are continually recalculated and hence modified to a greater or lesser degree. The combination of the representation of the outside world, its subjective, situational valuation and the awareness of this valuation form the consciousness.

This can be used to explain the newly developed model structure based on neuropsychoanalysis. Initially, we differentiate three principal layers (Fig. 3.11, right-hand image). The bottommost layer represents the hardware of the neurons and follows the neurological model concept. A clear hierarchical structure exists here [Pra 06, Bru 07]. The topmost layer represents the psyche, i.e. the psychoanalytical model, which is not similarly organized hierarchically within itself, however, since it is a decentralized, distributed functional model. For this reason, the third layer is represented as associating spheres in the left-hand image in Fig. 3.11. According to [Bra 04.2], neurosymbolization is positioned between these two layers.

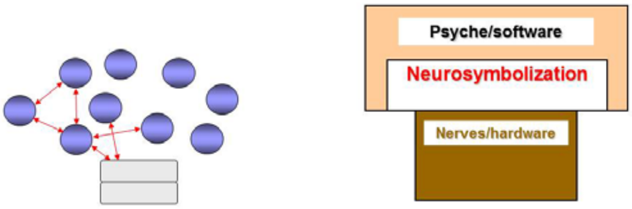

Fig. 3.11: Interrelation of hardware and software
(on the left, layer 3 of the model is shown as a distributed system)

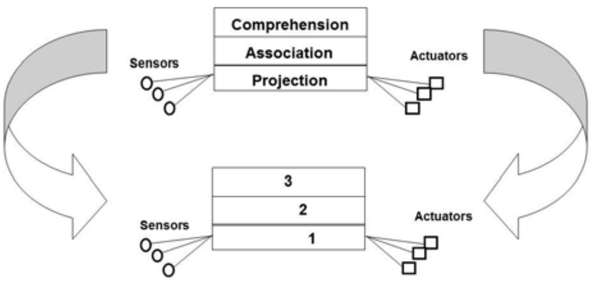

Fig. 3.12: Hierarchical model of the neuronal systems according to [Lur 01] (top)
and the SiMA model to be developed from it (bottom); see similar Fig. 5.1

Prior to [Sol 04], Lurija [Lur 73] was the pivotal figure who developed the hierarchical model of the brain as shown in Fig. 3.12 (top). It is similar to the model of information theory of computer technology (Fig, 3.12, bottom), but not identical. Comparatively simple operations [Bur 07] like movements of the hands or eyes, are controlled in the two lower layers of Lurija's model and can be readily localized within the brain using imaging systems. These represent connections to actuators like muscles or glands which we describe in form of hardware. In recent years, great progress has been made in this area thanks to measurements using MRI. But the higher up the actions are sited, the more diffuse the assignment of functional units to physical units becomes. For comparison we may look at the processes at the transistor level in computers: The higher up one goes in the hierarchy between transistor and applications, the less easy it becomes to associate individual functions with concrete transistors. One would never attempt to assign, for instance, the function of receiving an email to a certain set of transistors. To be able to understand the interconnections, one observes the individual layers of the system and relates only adjacent layers with one another. The same must presumably be done in the analysis of the brain to make its interconnections more easily understandable.

This is the decisive reason why we use a modified model in information theory of computer engineering. In his concept, Lurija failed to differentiate clearly between functions and hardware – which is understandable when one considers that some functions can be distinctly located in certain regions of the brain. Whether these functions are exclusively located in these regions, however, cannot be conclusively proven even today. The resolution of MRI systems is simply not high enough. Therefore computer engineering follows a strict ruleset by defining the first layer as a pure hardware layer and all layers above it as pure functional layers, regardless of their physical nature. This point will be taken up again in Chapter 5.1.

It becomes apparent that a forceful attempt to bring the neurons into direct correlation with the consciousness is pointless and inefficient. Even though it is ultimately the neurons which form the basis for the existence of *complex* process of consciousness, it will not be possible to develop an understanding of the functionality of the consciousness solely on the basis of understanding the functionality of the neurons. Sigmund Freud recognized this more than 100 years ago in his treatise [Fre 01], but many of his modern-day colleagues have still not understood the implications – as explicitly pointed out in the introduction to this report.

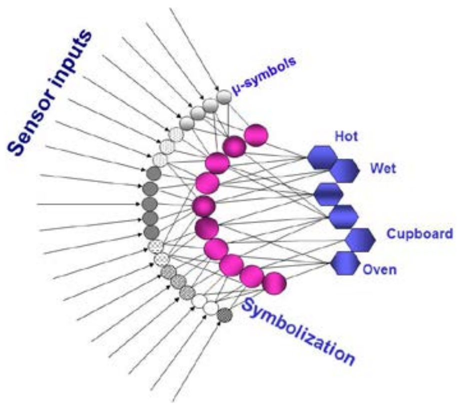

Fig. 3.13: Projection field; in the SiMA computer model, commensurate to the bottom image in Fig. 3.12

Armed with these basic considerations, the various layers of the psychic apparatus can be modeled in greater detail. The bottommost layer in the top image in Fig. 3.12 is the projection field already comparatively well-researched by Lurija (see also [Pra 06, Bur 07, Vel 08]). Here the data coming in through the sensors (hardware) are first condensed into micro-symbols and then into *symbols* in various sub-layers (in Fig. 3.13, this process is illustrated from left to right), a process which computer engineers often refer to as *mapping*. The symbols ultimately obtain meanings like *hot*, *oven*, *fast movement*, etc. – this occurs in the second (middle) layers in the computer model in Fig. 3.11 and the psychic model in the bottom image in Fig. 3.12.

The symbols are the interface values for the transition between the functional layers 2 and 3. They can be *drive symbols, images* or *motions*(see detailed description in Chapter 5). Actions of longer durations are called *acts*, but these acts require the consciousness. According to [Sol 04, Dam 01], in order to understand acts it is necessary to differentiate between the *core consciousness* and the *extended consciousness*. The core consciousness, located in the brain stem, provides the organism with a sense of self which is momentary, i.e. it applies only to the here and now. This is the only responsibility of the core consciousness [Dam 01, p.28f.]. It conveys moments of experience as momentary aggregations of self-states and simultaneous events in the outside world. An important role in this system is played by the hippocampus, a folded lobe of primitive cortex closely associated with a group of structures known as the *limbic system* and linked to dimensions of *valuation*. [Sol 04, p.176f.] refers to the valuation as *emotions*, but as will be shown in Chapter 5, the valuation quotas in the psyche, i.e. the third layer, must be clearly and strongly differentiated. They range from quotas of affect all the way to feelings which have to be assigned specific tasks. One could say that valuation quotas like emotions represent living memories at an “initial, low level of representation” [Sol 04, p.289].

In comparison to the core consciousness, the extended consciousness has a much more *complex* form which endows the organism with a higher sense of self, namely with identity and perception as a person. The past can be remembered in sophisticated ways, and the future anticipated with similar *complexity*. Once again, the functions of the hippocampus play a decisive role: They allow the association of the immediate experience provided by the core consciousness with memories of past moments of consciousness. Here self-awareness in feeling and imagination form the *topmost level of representation* [Sol 04, p.290f.].

The *lowest level of representation* compares incoming information with the large database in which all the symbols[42] (drive symbols, images and motions) gathered throughout a person’s life and their subjective valuation are stored. The results of this comparison are the quotas of affect which serve as an initial valuation template for a perception. Perception thus means that symbols are used to create a presentation of the outer world [Die 04a] which is brought into relation with memories, i.e. already existing stored presentations, compared to them and identified through them. The result of this identification is the representation of perception in the consciousness. Hence we view the representation as a functional value which retroactively affects all associated symbols. This in turn means that all symbols (drive symbols, images and motions) are always stored with a valuation[43], and that all retrieved symbols likewise possess a valuation (quota of affect, basic emotion, extended emotion, psychic neutralized intensity and feelings). Following this train of thought to its conclusion, we discover that humans can never judge truly objectively, but instead invariably evaluate situations in the context of their personal history and thus in a highly valuated manner – an “emotionalized” manner, as psychoanalysts would say. The supposed objectivity results from the abstracted consideration of one’s own history and generalization onto the entire society.

[42] It must be taken into consideration that the axiomatically defined term “symbol” has a different meaning here than it does in psychoanalysis. In the presented context, it is based on the meaning in information engineering.

[43] Psychoanalysis uses the term *cathexis* in this context.

Compared with the extended consciousness, the functions of the core consciousness require only a relatively low neuronal mass. Consciousness in an enhanced sense cannot occur in the core consciousness for the simple reason that there is not enough “computing capacity”. Conversely, however, more neurons do not necessarily create higher consciousness. This means that the realm of feelings does not exist in the core consciousness, either. The extended consciousness (see above) is the requirement for a being to have an image of itself – an awareness of itself. This does not refer to the ideal image that a being has of itself, but to the current image it has of itself – how it feels at this very moment. But where does this feeling come from?

This takes us to the *second level of representation*. The information from the outside world encounters the image that the being has of itself, thus signaling that there are two worlds to deal with. One might say that two spaces are created: The first is formed by the being with its own physical body, the other space is the rest of the world. This allows the individual to define itself, a faculty which human children develop at an age of around 18 months [Dor 01]. It sees itself in the mirror. It is thereby also able to experience itself separately from its mother and contrasts itself with its environment permanently thereafter. This experiencing is conscious, but its consequences are only felt to a very limited degree. The results of this representation experience are feelings, a form of valuation scheme. However, the feelings affect the entire mental apparatus and – in contrast to emotions – can no longer be localized.

The second level of representation of the extended consciousness, and thus the third level of representation overall, uses a model of the outside world as its background, with everything below this level referred to as the inside world. Once again, the terms “inside” and “outside” refer to the realm of the mental, thus the outside world includes the physical body of the being itself as it is outside of its thought processes. In other words, the outside world is the physical world inside and outside our bodies. The thick callus on the soles of my feet is an excellent example. It is physically a piece of me, but my image of the world outside my body, perceived by my sensors, does not show it. Hence I do not “feel” the dead callused skin – I do not “see” it with my “inner eye”, I am only able to sense it by touch from the “outside”. The inner world is therefore a pure model concept and does not correspond to the real world.

Another aspect must be mentioned in this context: The concept of acts, introduced above in the context of motions. If an image of my own person exists, i.e. if I can register myself in the mirror, then it becomes possible to look into the past and gauge the future. But since everything is always stored in a valuated form, we must also visualize our view into the past as one that is modeled and processed. The image of the past is increasingly modified by additional processing, sometimes more, sometimes less. For us engineers, looking back into the past, is currently not as important as looking into the future (knowing full well that the one is not possible without the other). The extended consciousness and its two additional levels of representation allow us to make plans. If we look at temporal processes beyond motions, we arrive at the acts which the mental apparatus must piece together using extensive processes. In order to do so, it simulates different variants of how to proceed and eventually decides on the optimal variant – with the optimum always being in reference to the evaluated data coming together in the psyche. Herein lies an essential advantage of evaluating possible action sequences: Conscious planning does not need to calculate *all* possible action sequences. The chess player Garri Kasparov, for example, always only calculates a few moves in advance, but can resort to vast experience with the game, while the chess computer *Deep Blue* calculates millions of possible move combinations during each of its turns [Sto 97].

4. Use-cases

A device or software is created in order to observe and/or regulate a process (in the sense of automation) or in order to be able to transact a process (in computer engineering, one often speaks of an application), e.g. wireless communication. For example, when developing the electronic processors (chips) for an iPhone, then according to the top-down design principle one must begin by considering the application, i.e. the process itself (e.g. the operating system of the iPhone or its apps like the integrated clock or the telephone unit). To do this, questions must be answered first (in order to define the functional requirements for the topmost layer in the top-down design): How will the customer want to use the iPhone? What is the requirement profile? Which basic applications must be implemented by default? Which central functions shall be available to the integrated applications? And many more similar questions.

In keeping with these considerations, we must also start by examining the process (application) in our project to develop a bionic system corresponding to the human nervous system. In psychology, this process is represented by *use-cases*. Three use-cases are defined for the version of the simulation system presented in this report. These three comparatively “simple” cases are formulated exclusively by the psychoanalysts in the SiMA team so as to prevent any notions of engineering or classical artificial intelligence from being introduced.

The presented use-cases assume persons (agents) into each of which an autonomous mental apparatus[44] is integrated. These persons live in an artificial environment that is precisely defined, but whose parameters can be varied at will. The female agent in the SiMA project is nicknamed Simana, the male agent Simano for general purposes, though the concrete agents in use-cases are given individual names like Adam or Bodo (for male agents).

The first use-case (UC) was designed by Zsofia Kovacs and revised by Klaus Doblhammer[45] (both psychoanalysts). There followed a joint psychoanalytical and technical coordination by the team to determine what was currently implementable. Each use-case is eventually converted into technical

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[44] The term “brain” is intentionally not used since the simulation initially only comprises the third layer, i.e. the mental apparatus. Development of the second and first layers must be left for further projects during which the simulation packages are integrated into physical robots like Romeo – a process that is already being considered.

[45] Zsofia Kovacs and Klaus Doblhammer are/were staff members of the ICT at Vienna TU [1; 3] and active as psychoanalytical researchers for the SiMA project.

use-cases (tUC) by the scientific engineers in the course of their theses, a process which requires a host of knowledge about such implementations as well as experience.

The following aspects must be differentiated within each use-case: the initial situation (basic conditions), the history of the agents and the actual sequence of events, as the psyche is determined by the history. In order to make the document easier to read, the history and sequence of events are interwoven in the description of each case.

The mental processes in a human brain are not completely measurable or traceable in their *complexity*. Furthermore, only an extremely simplified system/model should be used in the initial stages of development of a concrete, elaborate computer model in order to keep the complicate structure manageable. Only once validated results are available can additional and more in-depth findings be incorporated.

4.1 Use-case 1: Adam seeks Schnitzel (AsS)

A highly simplified object interaction level was chosen for the first use-case in order to depict basic inner-psychic processes in the mental model.

Goals

The first use-case must be kept as simple as possible in order to be able to model, implement and test the basic framework as easily as possible. Any complexity not strictly required must thus be eliminated. The highest priority must be attached to proving the concept's feasibility and to testing and validation, not to the completeness of all possible human functional units – which is not possible in principle because it is a *complex* system - or the programming of the agents' history, but:

1. demonstrating the conflict between inner needs (hunger) and super-ego demands,
2. association of memories,
3. selection of defense mechanisms and
4. simple action planning.

Initial situation

The use-case "Adam seeks Schnitzel" (AsS) features a scene containing three objects:

1. the SiMA agent named *Adam*, bearer of the modeled mental apparatus,
2. the SiMA agent named *Bodo*, passive bearer of the modeled mental apparatus, and
3. the food source "*Wiener Schnitzel*".

The focus of observation are the processes within Adam's mental apparatus, with attentions focused in particular on the fate of the nourishment drive as a drive of self-preservation, i.e. on its genesis and progression, and the possibilities of drive discharge. Generation of pleasure and avoidance of unpleasure are the significant factors in this context.

At the beginning of the scene, both Bodo and the Schnitzel are outside of Adam's perception range.

Scene

Adam is hungry. This means that his empty stomach and low blood sugar level are producing drive tensions within his body via homeostasis. These drive tensions rise over time when Adam does not eat. There is an attractive source of nourishment nearby, but Adam is not yet able to see it.

Adam cannot cope with the rising drive tension. He shows an impulsive personality. Based on the early childhood development his ability for drive deferral is characterized in a specific way: The increasing drive tension (unconsciously) causes aggression, meaning that the aggressive component[46] of the drive tension in his drive representative is far higher than the libidinous component[47].

Due to his strong impulsivity and the upbringing associated with it, Adam also has a very strict super-ego. This super-ego is now activated because the drive tension from his growing hunger is becoming too great. This results in a conflict between the aggressive demands of Adam's hunger and his super-ego.

The conflict is this: I am hungry, I need to eat something now. The super-ego says "no, you may not eat, you must wait". The ego mediates by saying "I can satisfy the super-ego's demands by converting the aggression into anxiety (= affect reversal), I can satisfy the id by reducing or displacing the quotas of affect[48], and I can meet the demands of reality by deferring the nourishment drive representative and find realistic ways of searching for food."

What is the result? The aggression is not allowed (and neither are thing presentations associated with it[49]), and the affect reversal "anxiety" emerges through the ego's mediation using the mentioned defense mechanism. Furthermore, the drive tension[50] is redirected from the body and the drive track to the faculties of perception and rational thinking[51].

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[46] Aggression is the component of a drive tension that, in its attempt to satisfy itself on or with an object, wishes to disassemble or destroy that object. The split of drive tension into libido and aggression occurs in a way specific to a person's personality and current situation.

[47] Libido is the component of a drive tension that, in its attempt to satisfy itself on or with an object, wishes to create larger units (e.g. incorporating and absorbing an apple by eating it, or sexual union). What does this mean? Libido requires an object for its satisfaction, as does aggression. A relationship is established between the agent and the object, which for the satisfaction of the libido strives for larger units (i.e. creating relations between objects to form larger units, while aggression wishes to destroy this unity.

[48] Cathexis is the assignment of quotas of affect to psychic contents (thing presentations). This also means it is possible for cathexes to be removed or shifted by various functions of the ego. In the case at hand, it means that the cathexes are desexualized (removed from the drive track) and used for planning in the secondary process (e.g. searching for food).

[49] This refers to all memory traces which are cathected with aggression. Such an aggression can for example be directed at insects that happen to be in the room. These insects would then also cause anxiety, however, and increase the anxiety resulting from hunger through affect reversal.

[50] In psychoanalytic use, drive tension is referred to as drive energy, but this term implies a dangerous mechanistic parallel conclusion.

[51] *Thinking* describes the activation and processing of psychic content within the primary process (in opposite to *reasoning* in the secondary process). A *thought* is the result of the process *thinking*.

Prior to the defense mechanisms, quotas of affect are also subtracted from other drive representatives (e.g. those on the sexual track) because Adam has a comparatively mature ego. These quotas of affect are subsequently also used for the functions of the ego (perception, thinking, symbolization in the psychoanalytical sense) in the form of desexualized drive tension.

The original cathexis value[52] of the drive representatives is thus split up. The inner perception now causes hunger and anxiety to become conscious, i.e. the contents and affects are connected with word representations and are hypercathected[53] using neutralized psychic intensity. This hypercathexis is applied to edible objects in order to focus Adam's perception on them. His psyche then executes test sequences (reasoning, which in turn causes feelings (= valuation)), meaning that the possibilities of searching for food are considered. Finally, a decision is made which ultimately activates Adam's motor neurons.

Adam approaches a food source in the form of a Schnitzel and eventually notices it. Once again, conscious reasoning processes are triggered, deliberating whether the Schnitzel can satisfy Adam's need for nourishment, whether it might not agree with his stomach, and so on. Ultimately Adam decides to continue approaching the Schnitzel.

In doing so, he eventually also notices Bodo within his perception range. Unconsciously, this perception of Bodo is associated with memories of Bodo and the respective memory chains which reach all the way back to Adam's older brother. This process includes the association of experiences with Bodo and Adam's brother – for example that the latter used to often stand in his way, that Adam had to share everything with him, was afraid and envious of him, while at the same time also admiring him. Their previous fighting between the brothers over Schnitzels now becomes a fight for their mother's love in Adam's fantasy. The cathexes caused by this brotherly rivalry cause additional aggression to be generated from Adam's perception of Bodo.

Adam's stern super-ego is activated by this aggression and the fantasies of being beaten and wanting to beat in return, and his ego uses the defense mechanism (affect reversal) to convert the aggression into anger and the anger into guilt, with the fantasies of striking his opponent remaining unconscious.

The prospect of imminent confrontation or avoidance evokes memories of previous fights with his brother in Adam, and they associate with drive contents on the sexual track. Existing oral, anal and genital drive components are thus integrated. These quotas of affect are partly additionally desexualized and thus become available to the functions of the ego, and in part influence – via defense mechanisms (sublimation, turning against one's own person) – Adam's decision making.

[52] In psychoanalytic use, the cathexis value is referred to as psychic energy, which once again implies the physical term "energy" and its behavior. However, cathexis is a (valuation) quota of information engineering and hence time-independent, as it has no mass and therefore no connection to speed.

[53] Hypercathexis is the cathexis of psychic contents with psychic intensity above a certain threshold. Besides the connection with word presentations, this is another prerequisite for consciousness. The necessary psychic intensity originates from neutralized psychic intensity used by the ego on the one hand, and from the cathexes of the word presentations themselves on the other. Hypercathexis causes focusing of attention.

For Adam had always resolved his earlier erotic brotherly conflicts by giving up and submitting to his brother.

The anxiety and feelings of guilt now become conscious (through word presentations and hypercathexis as before). This does not mean, however, that all associations in this context become conscious – Adam only becomes conscious of the corresponding unpleasant feelings.

Through the connection with the word presentation of his name, Bodo is recognized as “Bodo”.

Adam’s reasoning sets in once again and deliberates the relation between anxiety, guilt and Bodo – in regard to the Schnitzel and Adam’s hunger. The following alternatives are considered for planning:

1. His ego decides on a compromise, similar to how he had always done before: to retrieve the Schnitzel and share it with the other agent.
2. His super-ego is not strong enough; his drives break through, causing him to grab the Schnitzel and eat it up.
3. His ego complies with his anxiety, which is larger than his pleasure gain from eating, and he gives the entire Schnitzel to the other agent.
4. His ego lets the aggression through; he attacks the other agent and channels his entire anger into the fight, biting and scratching and becoming sexually aroused. This is the same general scheme of drive breakthrough as in option 2.
5. He takes no action whatsoever, unable to decide what to do.

Once Adam has decided on a plan which offers him the greatest gain in pleasure / least gain in unpleasure in the long run, the appropriate action is taken.[54] Many aspects can play a role in this context: the pleasure of the id (sexual pleasure), the pleasure of the super-ego (e.g. pleasure derived by a moralist from self-chastening), or the pleasure of the ego (e.g. pleasure derived from thinking).

4.2 Use-case 2: Adam and Bodo (AaB)

The purpose of use case 1 is to validate the developed functional model of the mental apparatus and its basic principles. In particular, use case 1 illustrates the principal mechanisms of decision making (see model representation in Fig. 5.13, F48: Generation of Drive Components, F26: Decision Making, F52: Generation of Imaginary Actions, F29: Evaluation of Imaginary Actions), the relevance of the pleasure principle and its interaction with the reality principle. The processes fundamental to the exemplary activities like eating, sharing, giving and fighting represented in use case 1 are thus described, thereby establishing the premises for testing and verifying more complex behavior and its underlying principles.

Use case 2 aims at validating nearly all functions of the developed model and handling substantially more complex interconnections in terms of the agents’ behavior. In order to be able to reasonably

[54] All these actions, feelings, thinking and reasoning processes work with sexual drive intensity, although in some cases not much of this sexual drive intensity is visible in the end result.

represent this in a scientific manner, a deductive approach will be used in contrast to the above description of use case 1, and the individual sections of the description will be broken down in more detail. This means that the *initial situation* as introduced in use case 1, Chapter 4.1.2, will be placed at the beginning of the description of use case 2 and divided into three sections: introduction of the agent and his personality parameters, specification of the agent's predetermined memories, and description of the environment. The goals of the use case – discussed first in the description of use case 1 – will be separated into the research question and the decision situations in use case 2. Only the final aspect – the scene itself – will be treated in the same way as in use case 1.

The more complex scenario of use case 2 allows more of the model's functions to be analyzed and additional factors and *behavioral determinants*[55] to be identified, especially in regard to social interaction (e.g. in terms of emotions and their effects on the body, like blushing). With use case 1 having highlighted the significance of drives for the purpose of valuation, use case 2 can now also deal with the interaction of various *valuation quotas*[56]. Furthermore, Bodo – who remained passive in the first use case for reasons of simplicity – now becomes active, thereby placing new demands on the SiMA model and generating a host of agent interactions. This simultaneous simulation of two agents in use case 2 poses new questions and challenges.

In order to allow various dissertation topics to be derived from this second use case, alternative action scenarios in addition to the base scenario are described. All of these alternative scenarios are to be considered integral parts of the overarching use case 2.

4.2.1 Personality

The personality of an agent is defined through his personality parameters and his memories. The personality parameters are determined via the functions of the SiMA model; while they can change slowly over time, they are assumed to be constant for the purposes of simulation.

Personality Parameters of the Agents Adam and Bodo

In order to be able to describe personality-specific temperaments, it is necessary to define personality parameters which form the basis for the composition and processing of emotions. The two parameters used in the SiMA model are labeled *psychic emotion expression ability* and *bodily emotion expression ability*. Psychic emotion expression ability quantifies to what degree emotions can be

[55] To make the *use cases* utilizable as a base for technical implementation, they are converted into a structured, deterministic form (the so-called *simulation cases*). This conversion includes a description by means of which certain case states can be defined. Changes are achieved: (1) via certain environmental parameters; (2) via altering the agents' personality parameters; and (3) via the introduction and modification of memories. These three factors are thus labeled *behavioral determinants*, and for each alternative behavior in the *use case*, the corresponding behavioral determinants in the structured *simulation cases* must be identified. This allows the analysis of how – while using the same set of functions – the changing of data leads to a corresponding *change in behavior*.

[56] In the multi-level valuation model of the SiMA agent, emotions represent the next level of valuation quotas after the drives (which are part of the second layer of the three-layered SiMA model). Emotions subsume the drive valuations, the current pleasure level, and valuations activated through perception and fantasy.

expressed in a purely psychic sense (in Fig. 5.13, this process occurs in function F71: Composition of Extended Emotion, i.e. in the primary process). Bodily emotion expression ability quantifies to what degree emotions can be expressed in physical bodily functions, i.e. to what degree function F67: Bodily Emotion Reaction in Fig. 5.13 is capable of converting them.

The agents in use case 2 are named Adam and Bodo. Adam's personality is characterized by a low *psychic emotion expression ability*; his body is also configured such that it cannot easily express his emotions, i.e. he also possesses a low *bodily emotion expression ability*. His preferred defense mechanisms are reversal of affect and sublimation. His other personality parameters are inherited from use case 1.

In contrast to Adam, Bodo possesses a high *psychic emotion expression ability* as well as a high *bodily emotion expression ability*. In terms of partial drive distribution, Bodo's personality is oriented towards high phallic and anal partial drives, while the genital and oral partial drives are less pronounced. His neutralization rate for psychic intensity is also low, meaning that he has little psychic intensity available for ego-functions. Bodo's preferred defense mechanisms are projection and identification.

Memories of the Agents

Both agents have childhood memories of experiences with siblings. Adam had a younger brother; Bodo had an older brother and derived much pleasure from sharing with him. All other memories correspond to the description of use case 1.

4.2.2 Environment

In use case 2, both agents are in the vicinity of a Schnitzel, i.e. a food source. During the course of the simulation, Adam and Bodo mutually perceive and react to each other, resulting in manifold combinations of behavior and reactions.

4.2.3 Goal of the Use Case

In order to define the goal of an experiment, the research question as well as the range of decision options must be clearly stated.

Research Question

The initial situation leads us to the research question: How will Adam and Bodo behave towards each other with regard to the Schnitzel – depending on their respective personality parameters, memories and specific perceptions of the other's bodily state?

Range of Decision Options

Both Adam and Bodo are faced with decisions concerning how best to gain pleasure or avoid unpleasure. The drive object for both of them is the Schnitzel. Their decision options are limited by their predetermined memories and personality parameters.

4.2.4 Scenarios

A base scenario is initially defined, and two alternative scenarios with changed personality determinants are then derived from the base scenario.

Base Scenario

Adam is in a state of anger and fear, since (a) he is hungry with high aggressive partial drives and (b) he associates Bodo and the Schnitzel with anger. The action plan to eat the Schnitzel is valuated highly because the Schnitzel is cathected with quotas of affect from hunger (representative of a self-preservation drive) and the sexual drives (representative of the oral-libidinous partial drive). Both of these drives would be satisfied by eating the Schnitzel. Due to the emotions, which represent a further valuation quota in addition to the drive representatives, this valuation can however be changed. As a result of his memories, Adam’s anger and fear lead to different levels of activation (and thus valuation) of the actions of attacking, eating, and leaving, since these are the actions he has taken in the past when in similar psychic states.

Since the super-ego is not sufficiently activated due to the *low amount of neutralized psychic intensity*[57] and is therefore not strict enough, no sufficient change in the cathexis of possible drive objects and aims of drive occurs, i.e. the action to eat the Schnitzel remains the most highly valuated and is executed by Adam.

Alternative Action

If the libidinous partial drives of Adam’s drive representatives are predominant and Adam associates the memory of his brother and the Schnitzel with particularly high levels of fear, he will attempt to avoid the situation (as it causes him unpleasure) and leave. In this case the action plan to leave gains priority exclusively due to the valuation of feelings, which is sufficient to raise its valuation above that of all other possible action plans (eat, share, etc.), even though these other action plans are additionally valuated through cathexes. Therefore this scenario represents an unreflected action[58] since Adam does not check the action plan to leave due to his low amount of neutralized psychic intensity; here feelings serve as a means of short-term unpleasure avoidance.

Further Action Alternatives

If Adam’s specific personality affords his psyche a higher amount of neutralized psychic intensity, an inner-psychic conflict ensues because his super-ego forbids him to become angry. Depending on the available amount of neutralized psychic intensity[59] (predetermined by the personality parame-

[57] For the purpose of the use case, the amount of neutralized psychic intensity is predetermined and fed from the quota of affect.

[58] “Unreflected action” refers to an action triggered by the state of feelings and executed without closer evaluation in regard to long-term pleasure gain and unpleasure avoidance.

[59] A low amount of neutralized intensity causes reversal of affect, while a high amount of neutralized intensity (high ego strength) causes sublimation.

ters), the defense mechanisms will cause (1) reversal of affect or (2) sublimation. Reversal of affect converts aggressive emotional components, transforming anger into guilt. Sublimation on the other hand manipulates the aim of drive, transforming *eating the Schnitzel alone* into the socially more acceptable *sharing the Schnitzel*.[60] In this case, a part of the cathexes of the Schnitzel are allocated to another agent with whom it can be shared.

Depending on the strength of the active feelings – maybe also due to anger, fear and guilt – action plans to *share the Schnitzel* or *give* it to Bodo are activated. Depending on the amount of available neutralized psychic intensity – which in this case regulates the intensity of thought, i.e. of action rehearsal – the activated action plans are evaluated in terms of their pleasure gain and unpleasure avoidance. This eventually leads to Adam (a) *sharing the Schnitzel* or (b) *giving the Schnitzel* to Bodo instead of eating it himself.

4.2.5 Social Interaction

In contrast to use case 1, Bodo is also active in use case 2. Bodo's possesses a high initial level of libidinous hunger (as opposed to Adam), and Adam reminds him of his older brother.

Furthermore, Bodo takes into consideration the actions taken by Adam and adjusts his own plan accordingly; the same happens vice versa. Each agent must therefore be aware of the other's emotional state in order to react to it.

Bodo's memories cause a transference[61] to Adam to occur, which causes Bodo to cathect Adam as an interaction partner. This is because Bodo has memories of great pleasure resulting from sharing with his older brother. On the other hand, Adam is also holistically valuated via emotions, i.e. the remembered emotional valuation subsumes all detailed valuations by which Adam is associated as Bodo's older brother. This valuation by Bodo causes him to view Adam as dominant in their current situation, while at the same time also valuating him as the protecting brother.

Each agent's valuation of the other is determined by his own internal state as well as by the internal state ascribed to the respective other. The ascribing of emotions is the fundamental mechanism for gauging the internal state of the other agent. It occurs mostly unconsciously as a result of the perception of bodily factors like sweating, trembling, blushing, and facial expression, which are primarily the bodily expressions of emotions – though they may also originate from other physiological causes. Because his evaluation of these factors is based on himself and his own body representatives, each agent associates those emotions which are significant to him with the bodily state and facial expressions of the other.

[60] This super-ego rule applies only to Adam, as do the specific defense mechanisms used by his ego to resolve the conflict. Bodo's ego follows different defense mechanisms. His leaving of the Schnitzel to Adam is caused by a projection, the sharing by an identification.

[61] Transference refers to the sum of all cathexes of a consciousness-capable action or imagination through unconscious imaginations.

4.2.6 Situation of the Agents

As the agents are completely separate individuals, the situation must also be separately defined for each agent.

Adam’s Situation

Due to his bodily properties and his comparatively imperturbable temperament (he can endure his emotions more easily without them necessarily being expressed bodily), Adam is not sweating, trembling or blushing significantly despite his state of inner-psychic tension.

Adam associates fear with Bodo’s bodily state (see below). This ascription of fear to Bodo in turn influences Adam’s emotions by way of emotional transference. At the same time, however, Adam becomes more angry because – due to his association of Bodo with his younger brother and the corresponding emotional valuation – he feels dominant over Bodo.

Bodo’s Situation

Bodo is sweating profusely; he is blushing and even trembling lightly. He also associates anger with Adam’s bodily state and facial expression. As a result of this emotional valuation he submits to Adam’s dominance, thereby becoming more fearful and sad.

These emotional transferences represent adaptations to the internal state of the respective other agent. In addition to the previous emotion-creation processes, they leads to further modification of Bodo’s emotional state, which in turn influences his previous valuation of possibilities for action. Proprioceptive perception of his own sweating and blushing increases Bodo’s fear even more.

4.2.7 Results of the Use Case Variants

The different action variants described above should respectively lead to the following behavior in the simulation experiments:

1. Adam eats the Schnitzel alone (described in Chapter 4.2.4.1),
2. Adam avoids the situation and leaves (described in Chapter 4.2.4.2),
3. Adam leaves the Schnitzel to Bodo (described in Chapter 4.2.4.3), or
4. Adam gives the Schnitzel to Bodo (described in Chapter 4.2.4.3).

The experiments conducted in the framework of various dissertations should verify that the above-mentioned behaviors occur as described here. Should this not be the case, then there are two possible reasons as discussed in Chapter 3: There could be an error in the implementation, in which case the hitherto conducted theoretical work regarding use case 2 would not be affected. The other possible reason would be an error in the underlying theories, which would mean that the SiMA model would have to be searched for a mistake.

Since it can be assumed that the experiments will verify the theoretical SiMA model, they will also possess an even deeper meaning. Until today, psychoanalysis is primarily based on qualitative statements and testing. One of the fundamental tasks of SiMA is therefore to assign numerical values to the various parameters like emotions, neutralized psychic intensity, anger, etc. Not much progress in this direction could be made within the strict confines of use case 1, but use case 2 should allow significant improvements in this area.

4.3 Use-case 3: Pedagogic Interaction (BS)

The two use-cases described above have already been implemented. Realization of the first use-case has already yielded results which have been published [Bru 13]. The second use-case is currently being implemented, while the following third use-case represents the idea of establishing an interdisciplinary cooperation between pedagogy and computer engineering based on the model developed in SiMA[62]. The working title for this project is *Emotion-based decision-making simulation of pedagogic interactions* (or EBES as an acronym of the German *emotionsbasierte Entscheidungsfindungssimulation*).

The examples described in the following attempt to present pedagogic decision-making processes using simplified but precisely structured basic conditions. The actual conflict in each case is exchangeable. The environmental variables and person variables can be varied at will and amended or differentiated as required. Nevertheless, the conflict situations should initially be limited to a decision process.

The goal is a representation of emotion-based regulation mechanisms: why is which decision made, and when?

Scene

A two-year old child is playing with building blocks on the living room floor. It attempts to build a tower out of the blocks. After a short time, the increasing instability of the tower causes it to topple over with a loud noise, which surprises the child. It is now faced with a choice of whether to build another tower or look to its mother, who is sitting at the living room table doing her taxes. In this moment, the child feels insecurity and indecision.

The 35-year old mother is sitting about 10 feet away from her son and is concentrating on completing her tax declaration while her son is busy piling up the building blocks. In the moment she perceives the toppling of the tower, she enters into a conflict of her own, i.e. into the situation of having to decide whether to look at her child and (perhaps) rebuild the tower together or to continue working on her taxes, guided by the hope/wish that her son will continue to play by himself.

[62] Further approved research projects are underway which intend the SiMA model in order to more effectively use and regulate energy. For reasons of brevity, these projects cannot be described in detail in this report, but the elaboration and their results will be published in due course by team members.

Personality description and parameters

The mother is a 35-year old law office assistant. She is living alone with her son in a small apartment in Vienna, having separated from her son's biological father during her pregnancy due to irreconcilable differences and having broken off all contact after the child's birth. Despite her parents' financial assistance, she can barely find time for herself next to her job and the upbringing of her son. Towards the outside, she is a self-sufficient and self-confident woman, intent on not showing any weakness or need for help to her environment. On the inside, however, she has for quite some time felt the wish to be able to tend more to her own needs. The wish for a mature relationship and social contact in particular occupy her permanently, repeatedly leading to phases of depression. These feelings are pitted against those regarding most important person in her life: her son. She is currently working part-time in a law office in Vienna.

The son is two years and three months old. Pregnancy and birth were unproblematic. His development is appropriate for his age, and he exhibits a quite mature attachment behavior towards his mother. His urge to be active has increased dramatically in the past months, as has his desire to explore. He walks and climbs on his own and has no trouble getting around. However, his fine motor control is not yet very pronounced, a fact which seems to be occupying him heavily at present. His language development is also commensurate with his age; he knows about 100 words and can easily understand instructions. Nevertheless, his urge to communicate is not very great since his mother pays him a lot of attention. His toilet training is making progress but is not yet complete. For several months he has been attending a day-care center while his mother is at work.

The following ideas have been considered:

Protagonists: child and mother

(a) Child: bearer of the modeled mental apparatus, male, 2 years old
(b) Mother: bearer of the modeled mental apparatus, female, 35 years old

Decision situation

(a) Eye contact (seek contact with mother) or rebuild the tower alone (do not seek contact), child: "I want contact/closeness!"
(b) Eye contact (seek contact with child) or continue working (do not seek contact), mother: "I will provide contact/closeness!"

Variables (multi-causal)

(a) Active mother versus passive mother
(b) History of the agents (personality)
(c) Current body state variables (body perceptions associated with memory traces)
(d) Initial situation (current inner-psychic state) of the agents
(e) Environment variables

Possible questions concerning modeling

(a) What will the child decide to do, and why?
(b) What will the mother decide to do, and why?
(c) Which environment variables are necessary in order to " .. want closeness!" or ".. provide closeness!"?
(d) What constellation of variables (personality parameters) results in which decision situation?

(e) What are possible causes for certain decisions over others?

Central questions (pedagogic relevance/research interest)

(a) Precision of the variables and personality characteristics
(b) Does the employed model allow inferences in regard to basic assumptions of personality theories?
(c) Which deductions can be made from the simulation results regarding e.g. the significance of valuation quotas like emotions for decision-making processes?

5. The Psyche in the Neuronal Network as a Hierarchical Model

Based on the theories of the brain researcher A. R. Lurija [Lur 01], a hierarchical model is developed that possesses 3 layers (Fig. 5.1). One must bear in mind, however, that Lurija did not design his model in terms of information theory of computer engineering, but generally defined three functions[63] and assigned one layer to each of them. He arranged the layers hierarchically and named them projection field, association field and comprehension field. The sensors and actuators are in the lowest layer, the projection field. From a neurological point of view, certain brain regions can be assigned to these three layers, thus making it not strictly a functional one as required by computer engineers for simulations and emulations (functionality is mixed with localization). Hence the initial question was in what way this model could be modified to make it usable for computer engineering.

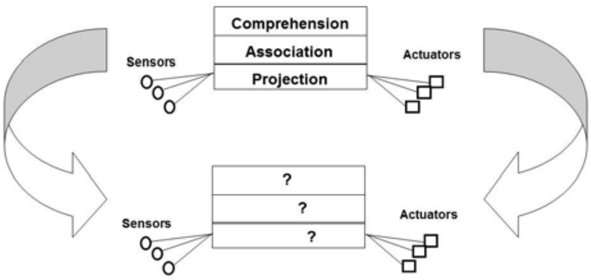

Fig. 5.1: Hierarchical model of the neuronal systems according to [Lur 01] (top) and the SiMA model to be developed from it (bottom); see also Fig. 3.11

Two model types from information theory of computer engineering were ultimately employed in the SiMA project: the functional (layered) model and the abstraction (layered) model. In the following, it will first be attempted to elucidate the difference between these models before going into detail on the different layers of the functional model.

[63] See also Chapter 3.14, Fig. 3.12.

5.1 Functional Model and Abstraction Model

The ISO/OSI model is a functional model. Its seven hierarchically arranged layers[64] represent different functions which have different tasks assigned to them (Fig. 5.2, left side). The lowest layer describes the hardware of the communication unit (the physical description component of the communication medium), while the layers above it are defined purely functionally and can therefore be implemented as hardware or software. As the layers perform different functionalities, the interfaces between them must also be functionally defined.

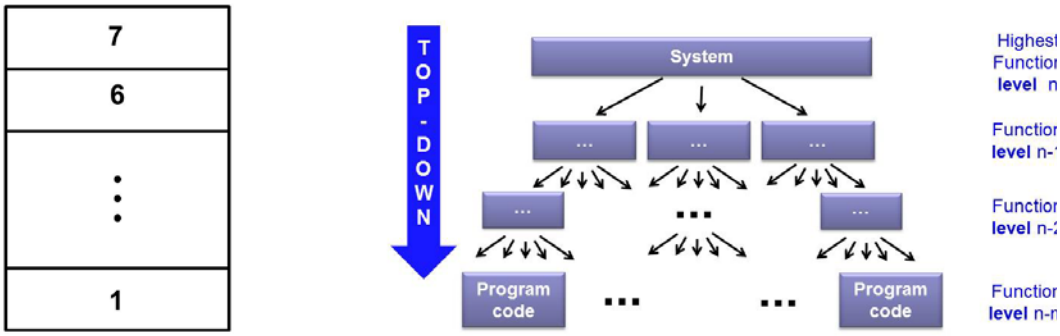

Fig. 5.2: Left: example of a functional model (e.g. the ISO/OSI model) on the basis of different layers, Right: example of an abstraction model based on levels

The abstraction model (Fig. 5.2, right side) is likewise hierarchically organized, but a different task than that of the functional model is assigned to it. The levels do not represent different functions (which is why the authors speak of levels in this context in order to make the differentiation more clear). Instead, the abstraction model is used to "break down" a model into sub-units, meaning that in the topmost level, a high level of abstraction is assumed in which relations are described very abstractly. One then disassembles each level into individual blocks and functions[65], repeating this process until one eventually reaches the programming code or hardware. Hence the levels all describe the same thing, but the bottommost level describes it in the most detail and the topmost level in the most abstract fashion. This means that each layer of a functional model can be represented in different levels of an abstraction model, with the intent of making complicated models more transparent. Every interface found in a certain level must also appear in all the levels below it, generally in a more detailed and differentiated description.

The model of the nervous system to be designed must therefore initially be described as a functional model, which is then broken down into layers and each layer into levels. In the following, a 3-layer functional model, and for its third layer a 5-level abstraction model as per Fig. 5.2, will be defined.

[64] The use of the two different terms *layer* and *level* is intentional and an attempt to avoid misunderstandings.

[65] The levels contain the functions of the layer they are associated with in the functional model.

5.2 The SiMA Functional Model

As explained in the introduction to this chapter, the SiMA project acts on the assumption of a functional hierarchical 3-layer model for the information unit of the human body (Fig. 5.3). It is intended to represent the human nervous system and should be understood as the control unit of the human body (see also [Die 09.1, p.410]).

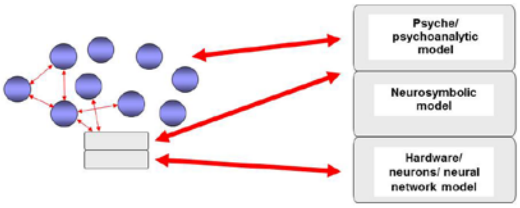

Fig. 5.3: Hierarchical 3-layer model of the nervous system; each layer is described via a (sub-) model (layer 3: a distributed system of functions which exchange information, as indicated in the left-hand part of the image)[66]

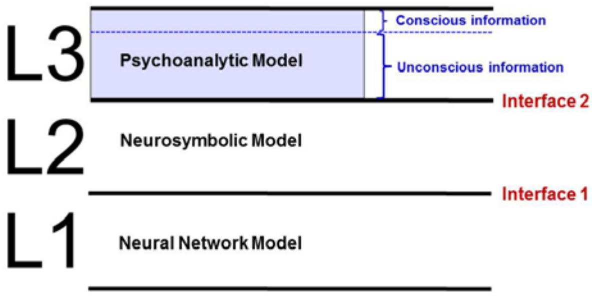

Fig. 5.4: Hierarchical layer model of the nervous system from the perspective of computer engineering (L3: Layer 3, L2: Layer 2, L1: Layer 1)

The bottommost layer (Layer 1) represents the description of the hardware (Fig. 5.4), i.e. the human nervous system on the base of physical, chemical and physiological knowledge. It depicts the neuronal network and includes all sensors and actuators. The model concepts of psychoanalysis are used for the topmost layer (Layer 3) [Die 09.1, p.406], and the middle layer (Layer 2) is considered the neurosymbolization layer [Die 09.1, p.106]. A fully fleshed-out model for Layer 2 does not yet exist. On the one hand, one must bear in mind that it is currently not possible to develop an information engineering structure for Layer 2 based on the hardware layer (Layer 1; see Fig. 5.4), the neuronal network with its 12 billion (= $12*10^9$) neurons and 1,000 times as many synapses [Dam 97, p.59]. On the other hand, it is impossible to look down into this Layer 2 coming from the "top", i.e. from the secondary process sublayer of the psyche in Layer 3, and attempting to look "down"

66 Multiple terms within one layer indicate the designations used in the SiMA project (on the base of the SiMA axiomatic with various meanings).

through the primary process sublayer which contains only unconscious information. Layer 2 appears not to be directly comprehensible to the human observer at this time.

When computer engineers are faced with this kind of problem, i.e. that the functions of two layers in a hierarchical layer model are known, but the layer between them is not, they define the corresponding interfaces (here: Interface 1 and Interface 2; see Fig. 5.4), and then develop a model for the desired layer using the requirements determined for it by the interfaces. That was the research goal postulated by Rosemarie Velik for her dissertation, and her achievement of this goal validated the feasibility of the 3-layer model [Vel 08]. It is not yet possible to validate more than this feasibility, as Interface 2 must first be comprehensively described as indicated in Fig. 5.4. This, however, can only occur – according to the top-down design method – once Layer 3, the psyche, has been sufficiently developed, which is why the current focus of the SiMA project lies exclusively on Layer 3. Hence Layer 1 and Layer 2 will generally be taken into consideration in the following descriptions, but only as far as necessary (i.e. in a very abstract fashion). In the simulation program, the data are mostly passed directly through Layer 2, as is currently also the case for Layer 1, the hardware of the SiMA project.

Another aspect is illustrated by Fig. 5.3 which was first mentioned in [Die 00]: the model is defined in three hierarchically arranged layers, with Layer 3 itself representing a distributed system of functions between which data (pieces of information[67]) are exchanged.

In the following, Layer 3 of the functional model, which according to the top-down design principle must be developed first, will be broken down into the levels as stipulated by the abstraction model. As is usually the case with the ISO/OSI model [Hal 88] or in SDL representations [Hog 89], the bottommost level will receive the number 1, with ascending numbers given to higher levels. Furthermore, within each level the tasks of the defined functions will generally be formulated in accordance with axiomatic considerations.

5.3 Layer 3 and Level 5 of the Psyche

The topmost level of layer three is level 5. It describes the overall function of the third layer of the information system *psyche*.

General Information

The original goal of the SiMA project was to understand and model in a bionic sense the functionality of human thinking, perceiving, feeling and acting in order to technically recreate the developed model as a regulation and control unit and examine its suitability for use in engineering. According to [Die 08, p.183], the psychoanalytical theories of the psychic apparatus – referred to as

[67] Data are considered carriers of information in this context, with the information content resulting from interpretation of the data.

metapsychology in the respective specialist terminology – are very well suited to this endeavor since Sigmund Freud[68] and thus (natural scientific) psychoanalysis satisfy the following principles:

1. The psyche can be viewed as a functional model on the basis of psychoanalytical theory (i.e. function and behavior are related to one another).
2. The psyche can be integrated into a functional layered model (Fig. 5.4).
3. The psyche can be divided into sub-functions (e.g. modularization into id, ego and super-ego).
4. The approach is commensurate with natural science: the observation of phenomena is followed by the postulation of hypotheses, which are questioned when contradictions arise,[69] and which have to be validated by use specific cases (see chapter 4).
5. Freud sought to find a clear and distinct terminology[70], which is now being developed systematically in a contradiction-free axiomatic fashion within the SiMA project (see attached NPyG).

As per point 3 in this list (division into sub-functions) and according to the methodological structuring as per Chapter 5.1, the psyche can be viewed as the highest functional layer (Layer 3, see Fig. 5.4). It can then be broken down into the various abstraction levels, with the members of the SiMA project eventually deciding on 5 levels. Hence the highest abstraction level is assigned the number 5. In the following, the breaking down into less abstracted levels will be elaborated starting with level 4, which describes the psychoanalytical functions id, ego and super-ego (second topographical model)[71].

Task of the Function at Level 5 (of Layer 3)

The psyche's task is to keep the process operating as efficiently as possible and regulate it appropriately.

5.4 Layer 3, Level 4: Id, Ego and Super-Ego

The development of the second topographical model by the founder of psychoanalysis, Sigmund Freud, represents the concretization from level 5 to level 4.

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[68] Sigmund Freud viewed psychoanalysis as natural science [Freud, GW XVII, 80f.] (see also Appendix Z1).

[69] Appropriate citation reproduced in Appendix Z1 [Freud, GW XV, 188].

[70] Appropriate citation reproduced in Appendix Z2 [Freud, GW XVII, 80f.].

[71] The standard for the functional model is to assign the bottommost layer the number *1*. Thus functional layered models are always numbered from the bottom up using numbers from *1* to *n*. Considering, for example, the abstraction language SDL (Specific Description Language), one can see that the same can be done for abstraction models. The disadvantage of this method is apparent: using the top-down design principle, one begins at the topmost layer or level, but what is its number? The consequence is that a renumbering is generally required upon completion of development of the respective model.

General Information

Significantly predating the epistemological position of radical constructivism, Freud developed a model of subjective human perception. Beyond this, he also saw himself as the third great affronter of humanity (following Copernicus' first affront, i.e. that the earth revolves around the sun, and Darwin's second affront, i.e. that humans evolved from apes)[72], as he recognized that "a part of mental life eludes the knowledge and authority of the will" [Fre 17, p.10] ("man is not master in his own house" [Fre 17, p.11]), meaning that unconscious thought processes make up a significant part of all thought processes. He claimed that a large part of what we would generally refer to as external sensory sensations in truth originated from unconscious valuation.[73] Freud used the metaphor of the ego, the psychic instance responsible for planning, reason and consciousness, being only a small rider on a huge horse signifying the id, the psychic instance representing unconscious wishes and desires.[74] The third psychic instance, the super-ego, introduces demands which originally come from authorities in the outside world and are internalized in the course of development as a child. It represents prohibitions, imperatives, rules and their interpretation.

The interactions between the three psychic instances as well as those with the body and the outside world are illustrated in Fig. 5.5. The psychic apparatus is affected by parameters from the physical/chemical world/physiological (= outside world), which originate in part directly from the body, e.g. from its proprioceptive perception or from the drives reproduced in the id as drive representatives[75]. The remainder of these factors comes from the environment, perceived via bodily sensors like the eyes and ears and already there being subjected to an initial processing[76]. These pieces of information from the physical world (= Layer 1) must pass through Layer 2 (the neurosymbolic layer) before reaching Layer 3 (see Fig. 5.4).

The manipulation of the outside world occurs via muscles and glands, whose "orders" are desymbolized in the neurosymbolic layer (Layer 2) before being executed in Layer 1. Hence

[72] Appropriate citation reproduced in Appendix Z3 [Freud, GW XIV, 108].

[73] The iceberg model, which was later derived from these considerations, is not Freud's invention [4; 5].

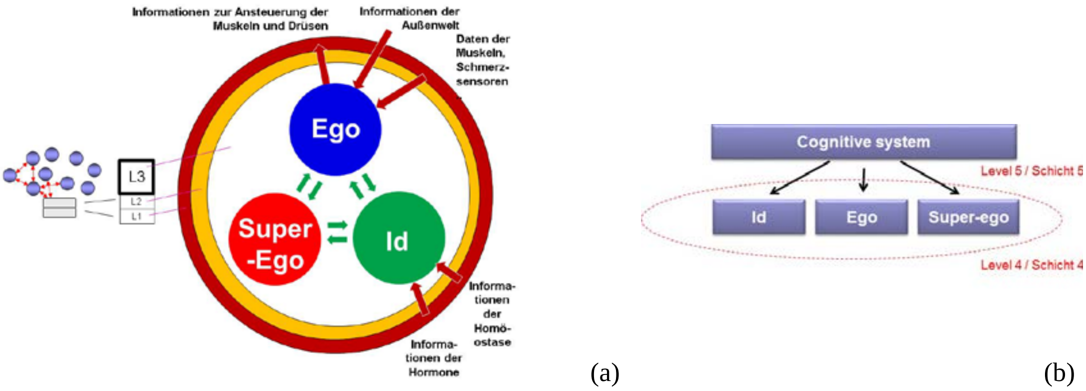
[74] "Thus in [the egos] relation to the id it is like a man on horseback, who has to hold in check the superior strength of the horse; with this difference, that the rider tries to do so with his own strength while the ego uses borrowed forces." [Freud GW XIII, 252, translation from: Freud. Standard Edition. Volume XIX, 24]. Therefore this means that the rider (the ego) does not completely control the horse (the id), but in fact only attempts to control it. The powers of the ego are borrowed in the sense that in psychoanalytical theory, the instance ego develops from the id, and as a consequence can only work with the intensities from the id (neutralized intensities).

[75] The term *drive* can only be applied to the body and its border regions with the psyche (neurosymbolization) in psychoanalysis [Freud GW X, 214]. In the psyche, the drive is reproduced as a *drive representative* using the drive source, aim of drive, drive object and quota of affect, with the source no longer having any significance in the psychic processing [Fre 15a, 210ff].

[76] Processing means that the incoming data are manipulated, i.e. changed, thus losing their original value. This fact in turn means that the information which we become conscious of in the top part of Layer 3, the secondary process, has already been adapted multiple times, and that we cannot actually determine or realize the original information in the secondary process.

according to the model concept of computer engineering (Chapters 3, Fig. 5.1 and Fig. 5.2), the entire physical nervous system (= network of neurons) is included in the physical layer (Layer 1), i.e. the *outside world* according to Freud [Fre 00, II/II, 616; Z4]. The psychic apparatus must be viewed as a purely functional (non-physical, non-chemical, non-physiological) layer.

Like in the other layers, feedback loops must be taken into consideration already in the physical layer. There are for example the reflex arcs, direct feedback channels between sensors and actuators via interneurons (e.g. knee reflex arc, testicle reflex arc).



(a) (b)

Fig. 5.5: (a) Layers 1 to 3, with Layer 3 (the three functions of the psyche) represented at level 4; **(b)** as per Fig. 5.2, level 4 is located underneath level 5 for Layer 3
(Layers 2 and 1 will not be broken down into levels in the following, i.e. represented in greater detail. The goal is to describe the psyche axiomatically and precisely before approaching the other two layers)

Feedback loops likewise exist in Layer 2, the neurosymbolic layer, but these feedback loops cannot be taken into consideration at this time for reasons of complexity; the same applies to the hormonal system, similarly a part of the communication and regulation system of the body.

Drives are defined as bodily needs determined by way of homeostatic processes like blood pressure, blood sugar, oxygen saturation, etc. Within the psyche, these drives are reproduced in the instance id as *drive representatives* via *drive source, aim of drive, drive object* and *quota of affect*. The super-ego manages internalized rules of the social world in the form of prohibitions and imperatives as well as the concept of the ego-ideal. When current situations and plans are associated with appropriate rules, the super-ego rewards or punishes. The ego is responsible for harmonizing the often exceedingly contradictory demands of the two other instances and the outside world in order to ensure the ability to act as well as possible.

According to Freud [Fre 15, X, 280; Z5], the psyche is described and governed by three principles: *topographic* (structural), *dynamic* (operative) and *economic* (operative).

The topographic aspect states that the psyche can be topographically (meaning functionally) broken down into sub-systems. In contrast to the theory of localization popular at the time, Freud thought that this topography could not be physically localized in the brain. He spoke of "theoretical entities" within the psyche and said: "Our psychical topography has for the present nothing to do with anatomy; it has reference not to anatomical localities, but to regions in the mental apparatus, wherever they may be situated in the body." [Fre 15engl; Fre 15, X, 273]. In modern computer engineering, such "theoretical entities" are called *functional units*. Sigmund Freud initially developed the first topographical model[77], and later the second topographical model[78]. In the first topographical model, he differentiated between the conscious/preconscious and the unconscious [Fre 38, 81; see also Appendix Z6]. The second topographical model comprises the instances id, ego and super-ego [Fre 38, 67ff.].

Freud was unable to harmonize his two models, blaming this fact on as yet undisclosed secrets of the psyche.[79] To this day, psychoanalytic theory has not been able to resolve the contradictions and unify the two models. However, using a more precise differentiation and with the help of information theory of computer engineering, this consolidation is now in the process of being achieved: if one views the second topographical model as a functional model with the corresponding instances, and the first topographical model as the associated data model defining the conscious/preconscious and unconscious data (contents), then the two models are not only compatible but in fact are necessary complements to one another, with each implying the other. The functions describe the structure of the units which process (manipulate) the conscious/preconscious and unconscious data.

Now let us discuss the other two fundamental terms from psychoanalysis necessary to understand the following.

The *dynamic*[80] aspect in psychoanalysis states that every psychic phenomenon is to be understood as the result of a conflict ultimately based on the demands of the drives [Fre 10, VIII, 22; see also Appendix Z7]. Hence the system is never static or balanced; contents from the id and the super-ego are constantly exerting pressure on the ego. This is a part of conflict theory, according to which the ego must develop defense mechanisms to be able to adequately react to the demands of the inner (psychic) world and the outside world.

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[77] *"Thus we imagine the psychic apparatus as a composite instrument whose components we shall call instances, or systems for the sake of clarity. […] The last of the systems […] we will call the preconscious […]. The system behind it we shall call the unconscious, since it has no access to the conscious except through the preconscious […]. The system following the preconscious is the one to which we must ascribe the consciousness."* [Fre 00, II/III, 542]

[78] *""I propose to take it into account by calling the entity which starts out from the system Perception. and begins by being preconscious, the 'ego', and [...] the other part of the mind, into which this entity extends and which behaves as though it were unconscious., the 'id'.3"* [Fre 23eng; Fre 23, XIII, 251]

[79] *What […] is the true nature of the state which is revealed in the id by the quality of being unconscious and in the ego by that of being preconscious and in what does the difference between them consist? But of that we know nothing. And the profound obscurity of the background of our ignorance is scarcely illuminated by a few glimmers of insight. Here we have approached the still shrouded secret of the nature of the psychical. [Fre 38eng, 22; Fre 38, 85]*

[80] Engineers will recognize that Freud is once again using a term here that has a specific meaning in physics. *Dynamics* refers to the effect of forces, and forces are derived from energy. In the psychic model, we differentiate several valuation quotas, from the quota of affect all the way to feelings (Fig. 5.7), which consist of different scalars that can represent the same parameters or work in opposition to each other (e.g. pleasure and unpleasure in emotions). The effect of the different cathexes (valuations) is referred to as dynamics in psychoanalysis, which matches the metaphor of psychic energy.

The *economic* aspect in psychoanalysis refers to the "psychic energy" in the system, which from the perspective of information theory (in computer science) must be viewed as a valuation system. In SiMA, the "psychic energy" is called *psychic intensity* (see Chapter 3.4), as the term *energy* is defined differently in natural science (Noether's theorem). In the psychic apparatus, psychic intensity is constantly derived from bodily organ tensions.

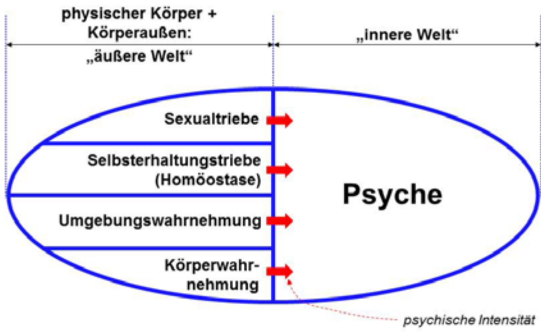

Fig. 5.6: The human information system shown as an ellipse,
divided into the physical (left half) and psychic parts (right half)
The creation of psychic intensity is a function of the id, resulting from sexual drives and the bodily function of self-preservation (self-preservation drives), but then reproduced in the psyche (red arrows) as a representative. The output of the psyche is not included in this image.

Psychic intensity consists of the combination of sexual tension and homeostatic tension. Sexual tension is the origin of the sexual drives (Fig 5.6)[81]; it is formed by hormonal parameters whose values are measured by sensors and represented in the id of the psychic apparatus. In psychoanalysis, this component is also known as *libido*[82]. The second component of psychic intensity is created via homeostatic tensions of the self-preservation drives (hunger, breathing, etc.).

In the SiMA project, psychic intensity is used as an umbrella term for all valuation quotas (Fig. 5.7). The quotas of affect are the valuation system formed from the neurosymbolic layer, the second layer of the brain (Fig. 5.4, Layer 2). It is processed and adapted in the various sub-functions of the primary process and eventually converted into emotions.

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[81] The blue border of the ellipse is supposed to indicate that the entire human nervous information system is being considered (i.e. all nerves and sensors, but not the body's organs like muscles, glands, etc.).

[82] *Libido* is a prominent term in psychoanalysis, but is unfortunately used in different ways in its theories. In Freud's late work (from 1920), it serves as the opposite of aggression to describe drive impulses seeking to create larger units. Within the SiMA project, libido is used in the sense of Freud's first drive theory: Libido is the representative of drive tension which originates exclusively from the sexual track. It is not used for drive tensions originating from the self-preservation track.

In addition, the term *libidinous* is used in SiMA nomenclature: this refers to those cathexes within the so-called fusion of drive whose discharge aims at forming larger units. The opposing term is *aggressive*, referring to those cathexes whose discharge aims at destruction and fragmentation. A drive representative always consists of both tendencies; this phenomenon is referred to as *fusion of drive* in psychoanalysis.

Valuation ultimately serves to prioritize actions in order to mediate between the demands of the outside world (the own body and the environment) and the inner (psychic) needs (e.g. satisfying psychic and physiological needs within the environment, or adapting (psychic) wishes to the external circumstances).

The foundation for the valuation of data (i.e. psychic parameters, up to actions and plans) is formed by valuation processes. These are processes which use quotas of affect or valuation quotas derived from them to determine the relevance of data – based on memories.

Valuation of data is an incremental process and occurs on several levels using various valuation quotas – under consideration of the pleasure principle[83], the reality principle, and valuation influences (body, memories activated by perception, fantasy). The interdependent valuation quotas (their umbrella term being psychic intensity) are: quota of affect, basic emotion, extended emotion, neutralized psychic intensity and feelings (Fig. 5.7).

But how do the individual valuation quotas actually valuate?

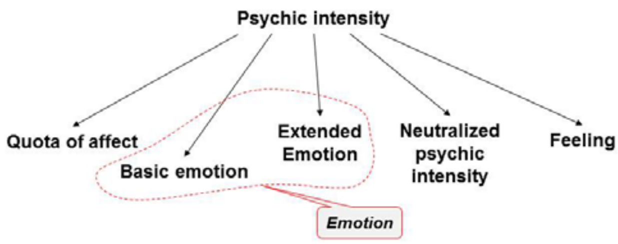

Fig. 5.7: Psychic intensity (umbrella term for the 5 defined valuation quotas of the psyche), with the term emotion subdivided into basic emotion and extended emotion

Quotas of affect are used for the valuation of psychic contents according to the pleasure principle (maximization of pleasure gain) in the course of the generation of drive representatives. Through this valuation (psychoanalytically: cathexis), possible drive objects and aims of the drive are defined. The drive objects and aims which provide the greatest pleasure gain according to memories are valuated as the best. Reality aspects (e.g. whether the object/aim is reachable or not) are not taken into consideration.

Neutralized psychic intensity valuates data under consideration of the reality principle and controls functions in the secondary process. The quotas of affect which are reduced in the drive track, and thus increase the valuation quotas in individual functions, are referred to as neutralized psychic intensity.

Emotion arises and valuates psychic content in the primary process Emotion is a vector calculated by quotas of affect with the scalars pleasure, unpleasure, aggressive and libidinous drive-components.

[83] According to Freud, the pleasure principle is one of two principles that command all psychic events: psychic activity as a whole aims to avoid *unpleasure* and attain *pleasure* [Lap 73, 297].

The information is unconscious. Besides its valuating function, emotion triggers somatic reactions. In the Secondary Process Emotion is transformed to feelings (see definition).

Valuation by way of emotions – and subsequently by way of feelings – occurs not only with a view to pleasure gain, but likewise with a view to avoiding unpleasure, i.e. not exclusively to support the fulfilment of wishes, but to valuate external circumstances in regard to the increase of unpleasure. The influencing factors of emotions are current *quotas of affect*, current *pleasure, and memories* activated by perception or fantasy; these factors are taken into consideration in the valuation process.

Depending on their processing, emotions are defined as *basic emotions* or *extended emotions* in the SiMA model. *Basic emotions* are *anxiety, anger, elation, saturation, mourning* and *joy*. *Extended emotions* form after *basic emotions* have been accentuated by the defense mechanisms. Examples for *extended emotions* are *envy, greed, pride, pity, guilt, depressive mourning, shame, disgust, hate with object or love with object*.

Feelings are the form of emotions capable of becoming conscious, and can be denominated by the agent with word presentations. The level of emotional intensity determines which emotions are transformed from the primary to the secondary process as *feelings* and thus can become conscious.

Feelings help to answer the question "What did I do before when I was in a similar state of feeling?", and valuate possible action plans correspondingly.

The total valuation quota, i.e. the sum of the individual valuations remains the same.[84] The valuation quota at a certain functional unit can be reduced, but at the same time the quota at a different functional unit must be appropriately increased. Psychoanalysis calls this condensation and displacement in regard to contents that are valuated. As per Freud, psychoanalysts once again employ an image from physics and speak of "displacement of psychic energy" (from a natural scientific standpoint: displacement of psychic intensity), or of "discharge" and "accumulation".

From the point of view of psychoanalysis, we see the concept of *cathexes* (from a natural scientific standpoint: assignment of a *valuation*) and their *movability* (from a natural scientific standpoint: possibility of *valuation displacement*). Freud defines cathexis as a process which attaches quotas of affect to memories and imaginations (in SiMA: drive symbols, image symbols and motion symbols) [Fre 15]. According to psychoanalytical theory, these are freely displaceable within the primary process, but not in the secondary process [Fre 20, XIII, 35]. At the transition from the primary to the secondary process, free psychic intensity is transformed into bonded psychic intensity, meaning the quotas of affect are affixed to the imaginations.[85]

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[84] „Hence the fully restored brain elements, even when at rest, emit a certain amount of energy which, functionally not exploited, increases the intracerebral agitation. This creates a feeling of unpleasure. Such feelings always result when a need of the organism is not satisfied. As the mentioned feelings of unpleasure dwindle when the released excess quantum of agitation is functionally exploited, we conclude that this removal of surplus agitation is a need of the organism, and for the first time we come upon the fact that the organism possesses a 'tendency towards keeping constant the intracerebral agitation' (Freud)." [Fre 95]

[85] Psychoanalysis assumes that available cathexes via quotas of affect are quite flexible via quotas of affect in the primary process, but stable in the secondary process. This means that different contexts of meaning can form via memory traces in

Tasks of the Functions at Level 4 (of Layer 3)

Id: The id is the instance representing the drive demands of the body, which urge for satisfaction following the pleasure principle. Mental contents in the id are organized along the principles of the primary process and hence the information unconscious.

Super-ego: The super-ego is the instance containing prohibitions, imperatives and gratifications and demands their observation. The unconscious information contained therein must be distinguished from consciousness-capable information provided by external social rules.

Ego: The ego synthesizes psychic processes and mediates between the demands of the id, the super-ego and reality.

5.5 Layer 3, Level 3: Sub-Functionality, Described in Greater Detail

The breaking down into levels below level 4 down to level 1 occurs – as is usual in research practice – in many iteration steps until one reaches an efficient resolution of functions at each level. The breakdown onto level 3, which will be explained in this chapter, is decisive due to the fact that the so-called *tracks* are defined at this level. Tracks represent the main flow channels of information. They are presumed to contain a number of feedback loops and functional bypasses, similar to the reflex arcs at level 1, but these phenomena must not be taken into consideration during the first step of development so as not to get lost in details at the start of a new research inquiry.

5.5.1 General Information

At level 3 of the abstraction model of Layer 3, the instances defined at level 4 are split up further. This occurs by searching for blocks with specific sub-functions which are clearly delimited from others. To do this, based on Fig. 5.3 the specific inputs and outputs from Fig. 5.5 are added in Fig. 5.8 (a), thus leading to the structure in Fig. 5.8 (b). This image is rotated 90° to the left to obtain Fig. 5.8 (c).

Layers 1 and 2 are simplified (since due to the top-down design principle in the SiMA project, Layer 3 is most interesting) by defining one function for each type of information flow, resulting in Fig. 5.9. This image shows the model like in Fig. 5.5 (a) with the respective colors, but divided into further sub-functions. At the top left are four input parameters (grey) which via the orange Layers 1 and 2 affect the psyche, specifically the green and green-blue blocks *drive track* and *perception*

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the primary process. One can say that the psychic intensity is “free” in the primary process, while in the secondary process the intensities are firmly “bound” to the contents, i.e. the meaning of contents capable of becoming conscious is stable in the secondary process.

track. After successful processing, the data are transferred to the blue-red function block *defense track*.

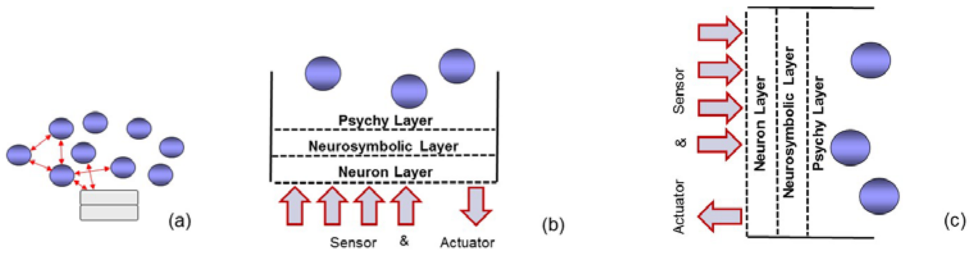

Fig. 5.8: Rotating the model
(a) corresponds to Fig. 5.3; in (b) and (c) 4 specific inputs and 1 output are added

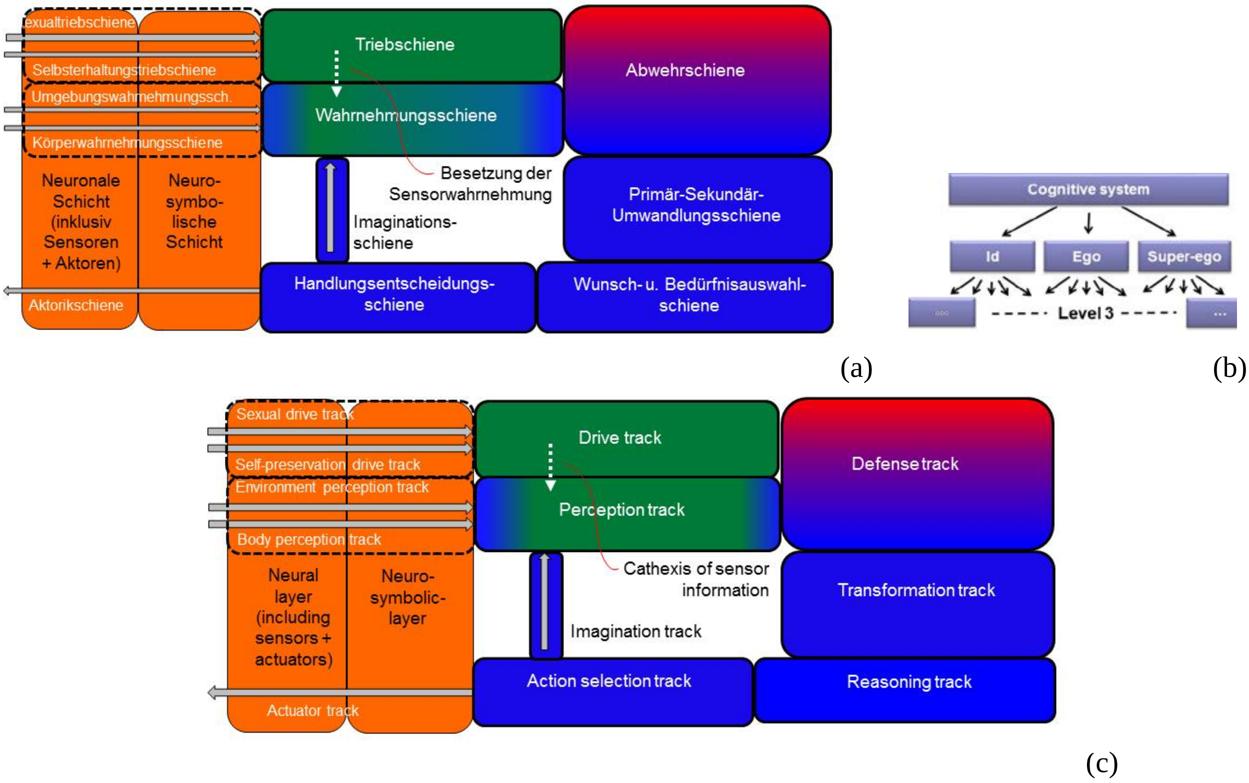

Fig. 5.9: SiMA model at the third top-down abstraction level
(a) German terminology, (b) level structure indication, (c) English terminology

These data are transformed in the primary-secondary transformation track at the transition from the primary to the secondary process, and subsequently reach the *reasoning track*. After this they are passed on to the *action selection track* and ultimately down through Layer 2 to Layer 1, where they represent the input data for muscles and glands (*actuator track*). The procedure is derived and described in detail in [Deu 11] and [Muc 13].

This process-oriented description method[86], which is based on control engineering principles, forms the basis for the description of processes and their control in automation. When applied to the human psychic apparatus, however, the problem of *synchronization* arises. All the billions of neurons in the brain operate asynchronously with each other. Unfortunately, in modern engineering nearly all simulation and process control is conducted digitally, since analog computers are hardly in use anymore. This means that one must decide between synchronous and asynchronous circuits – and synchronous circuits are generally preferred as they are easier to model, observe, implement and test compared. Asynchronous circuits have the unpleasant tendency to become unstable. In regard to Fig. 5.9, synchronous means that the model features a cycle, with one call (i.e. one activation) of each function from top left to bottom left occurring per cycle (Fig. 5.10).

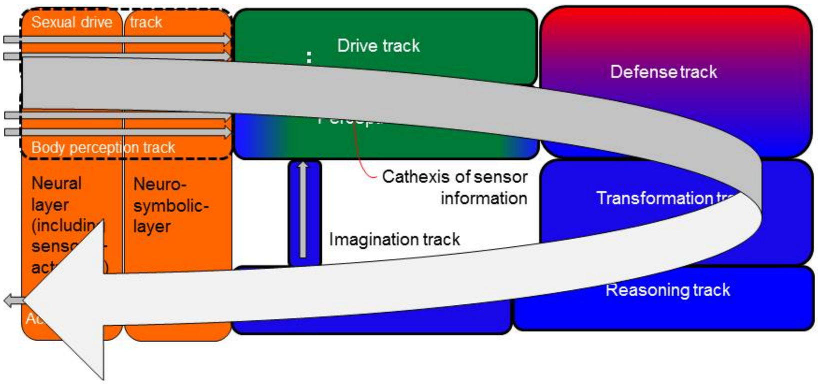

Fig. 5.10: Cycle route through the functions

Internal feedback loops like the integrated *imagination track* thus represent a principal problem area, since they can lead to asynchronous feedback loops which form the basis for instability. Furthermore, the cycle frequency must be adapted to the model as well as to the possible performance of the computer and the process to be controlled. The cycle frequency of the simulation must in any case be high enough to not create repercussions for the modeling, meaning that data flow speeds and processing speeds (and the associated delays) must not cause errors which would have to be considered in the model itself. Control engineering commonly assumes a factor of at least 10 by which the data flow speed must exceed the speed of the process to be regulated.[87] The selected value naturally has a direct influence on the precision of the simulation.[88]

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[86] In a control loop, e.g. a temperature control for a room, two basic units must be taken into consideration: the *controlled system*, i.e. the functional unit that is to be controlled (a radiator in this example), and the *controller*, i.e. the device which measures and maintains the temperature. In SiMA, the brain is viewed as an intelligent *controller* which regulates and controls the *controlled system* represented by the physical body. Hence a controller requires sensors and actuators and a processing unit – precisely the components found in Fig. 5.8.

[87] The factor 10 depends on the precision with which the process is to be run.

[88] This is the reason why this value should be substantiated with hard numbers in any scientific treatises like master theses or dissertations in order to prove that the simulation has no significant influence on the result.

Returning for a moment to the four inputs, they originate from sensors providing *homeostatic* information for the generation of *drives* (the *drive track* in Fig. 5.10) as well as information from the *perception of the body* and *environment* (the *perception track* in Fig. 5.10). All input values traverse the three layers of the model and are respectively modified and linked with other values. After conversion into mental representations (symbols: *drive symbols (quota of affects)*, *images* and *motions*) in the *neurosymbolization layer,* the input values reach Layer 3, the psychic apparatus – more precisely they initially reach the primary process (the upper part of the image in Fig. 5.10), where they are *thing presentations*. *Thing presentations* are unconscious, i.e. this information are not consciously accessible by definition [Fre 15, X, 264]. There is a differentiation between drive contents and perception contents, which influence each other to some extent, but are also processed independently. Hence it is possible for the psychic representative of a strong drive to influence perception (e.g. when one is hungry, one sees food everywhere and tends to buy more), but conversely the drive state cannot be influenced by perception since the bodily needs become effective in the psyche independently from the environment.[89]

The current constellation of drives and perceptions is represented in the drive and perception track – in context with memories – as wishes or perceived contents and then checked in the defense track, i.e. associated with its rules (imperatives and prohibitions). This generally results in conflicts between the demands of the super-ego and the formed wishes and perception contents. These conflicts are processed within in ego function using various defense mechanisms, i.e. the decision is made which contents can become conscious in what form [Fre 26, 196; FreA 36]. This process occurs in the blue-red defense track.[90]

Following the defense processing, the contents are passed on to the secondary process. The *thing presentations* are linked with *word presentations*[91] (in the *primary-secondary transformation track*), with the association rules following the spatial, temporal and general logic via the *word presentations* and being oriented along the *reality principle*. All contents in the secondary process are preconscious and can become conscious through attention control. The word presentations are a subjective representation of the natural language and structure the information material coming from the primary process according to temporal-logical rules and semantic contexts.

Next, in the *reasoning track*, the most important demand is chosen from the various demands (of the drives, the super-ego, and the outside world) processed in the defense track, with social rules and a first reality check being used as criteria as opposed to the pure strength of the cathexes like in the primary process. Then previously experienced actions and their results are remembered for this demand. The most suitable action, adapted to the current situation, is then executed.

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[89] Reference is made to this fact in [Fre 15, XIV; Fre 15a, X, 210]: “An instinctual stimulus does not arise from the external world but from within the organism itself. For this reason it operates differently upon the mind and different actions are necessary in order to remove it.”

[90] The defense process is not a simple filter mechanism, but in fact a modification of the conflicting information.

[91] A word presentation is a *complex* of associated presentations which represent a word of the natural language in the psyche. It also references the grammatical and semantic arrangement that a word has within the natural language.

5.5.2 Tasks of the Functions at Level 3 (of Layer 3)

The tasks are to be seen in the different tracks.

Drive track: The drive is a process within the body which creates a state of tension that orients the organism towards a certain goal. Drive representation and drive processing occur in the drive track.

Perception track: The perception track is responsible for the unconscious reception and pre-processing of sensor data and the forming of conclusions as to what the psyche should do in regard to this information.

Defense track: Functions of the super-ego and the ego are integrated in the defense track. The super-ego function is one of the three instances defined in the second topographical model; it holds prohibitions, imperatives and gratifications and demands their observation. The synthetic-integrative ego functions[92] decide whether and in what form drive wishes or perceptions are not allowed to be processed further towards becoming conscious. Hence their task is to resolve the principally existing conflicts in the primary process using the process patterns determined in the defense mechanisms.

Primary-secondary transformation track: The secondary process operates using different premises and procedures from those of the primary process. For instance, in the primary process time continually changes its dimension and causality plays no part, while in the secondary process temporal relations are respected and causal connections are observed. Therefore, we speak of thing presentations in the primary process and word presentations in the secondary process; these different terms comprise the very different modes [Zei 10]. The transformation of data to the secondary process occurs in the primary-secondary transformation track. Here, word presentations are attached to the thing presentations and subsequently structure the contents.

Reasoning track: In the reasoning track, the need is chosen which promises the greatest pleasure gain under consideration of external social rules and an acceptable level of unpleasure.

Action selection track: From all of the principally different possible action plans developed in the thought process, the one which promises the greatest pleasure gain based on the various valuations within the planning horizon is chosen.

Imagination track: The thought drafts not chosen in the action selection track are retained for further use by way of remaining imagined. This means that they initially continue to exist (preconsciously) as fantasies and subsequently unconsciously influence events in the primary process (in the perception track). The prerequisite for this further entry into the perception track is re-transformation from the secondary to the primary process via the imagination track, which at the least requires detachment from the word presentations.

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[92] *Synthetic-integrative function*: the ability to integrate potentially discrepant or contradictory with non-contradictory experiences [Be 75, p.423].

5.6 Layer 3, Level 2: Sub-Functionality, Described in Greater Detail

The processes in the drive track and the action selection track are relatively complex even in their basic functionality, making it appear sensible to break them down into a further level, i.e. level 2, before defining level 1 (Chapter 5.7) in which each function is developed individually.

5.6.1 General Information

According to psychoanalytical theory, the body and bodily organs constantly generate drive energy [Fre 15a, 212]. In the axiomatic system of SiMA, this parameter is called *drive tension* (Fig. 5.7). As it is not "energy" in the physical sense, but rather a valuation quota, it consequently cannot be *generated*[93] in a natural scientific sense and thus in the model concept of SiMA. Translated into the language of natural science, this means that the body and bodily organs demand a constant amount of drive intensity. This drive *tension* is specified by the neurosymbolic layer 2 of the drive track in Layer 3, the psychic apparatus. The part of the psychic intensity originating from the sexual track[94] is separated into individual partial drives according to personality parameters and makes demands of the psyche in the form of *sexual drives* which manifest as the aims of drives and exert their effect via the pleasure principle. The goal of these demands in the sexual track is pleasure gain. The self-preservation drives, which are generated by homeostatic processes, likewise make demands of the psyche, though their goal is not necessarily pleasure gain but rather a homeostatic equilibrium in the organ. This equilibrium only secondarily manifests itself as pleasure. The level of psychic intensity is measured in quotas of affect which are proportional to the original *drive tension*. Subsequently *drive objects*[95] and *aims of drive*[96] (*actions*) are remembered (associated) for all drives. The drive wishes thus generated capable of fulfilling the demands in the remembered sense. Psychoanalysis refers to this association of *drive tension* with drive object and aim of drive as the representative of the drive in the psyche. The term *drive* is only used in the context of the body (Layer 1) and the neurosymbolic layer (Layer 2). In addition, previously repressed contents[97] which are cathected with quotas of affect can appear in the current context.

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[93] Energy generation: the procedure demands to transform the energy from one form to another.

[94] This component of drive intensity is also referred to as "Libido" in psychoanalysis.

[95] A drive seeks to reach its goal (satisfaction) on or through a drive object. The drive object is the most variable component of a drive; it can be a thing, a person of the outside world or an imagined entity.

[96] The aim of a drive is an object-specific action which a drive urges towards and which results in a reduction of the drive tension within the respective source organ.

[97] Repressed contents originate from repression, a defense mechanism which prevents psychic contents which would generate unpleasure in a specific conflict case from being processed further. They are provisionally removed from the active process, but can attach themselves to future contents with their cathexes and thus become active again at any time (= return of repressed contents).

In the context of perception (perception track in Fig. 5.10), current perceptions (symbols, images and motions) are used (Fig. 5.11) to activate memories which are subsequently also processed for the current context. Repressed contents can also become active here. If for example there is a perception of an erogenous zone being stimulated, then libido is “discharged” according to psychoanalytical nomenclature. In terms of the SiMA axiomatics, this means that the corresponding quotas of affect from the respective partial drives (oral, anal, phallic, genital) are reduced, thus producing an according amount of pleasure. The current disposition at the level of quotas of affect and emotion is subsequently calculated from all quotas of affect from perception, which have been subject to multiple adaptations compared to the original sensory inputs. As all of these processes are located in the primary process, they occur unconsciously and thus cannot be subjectively reconstructed in humans.

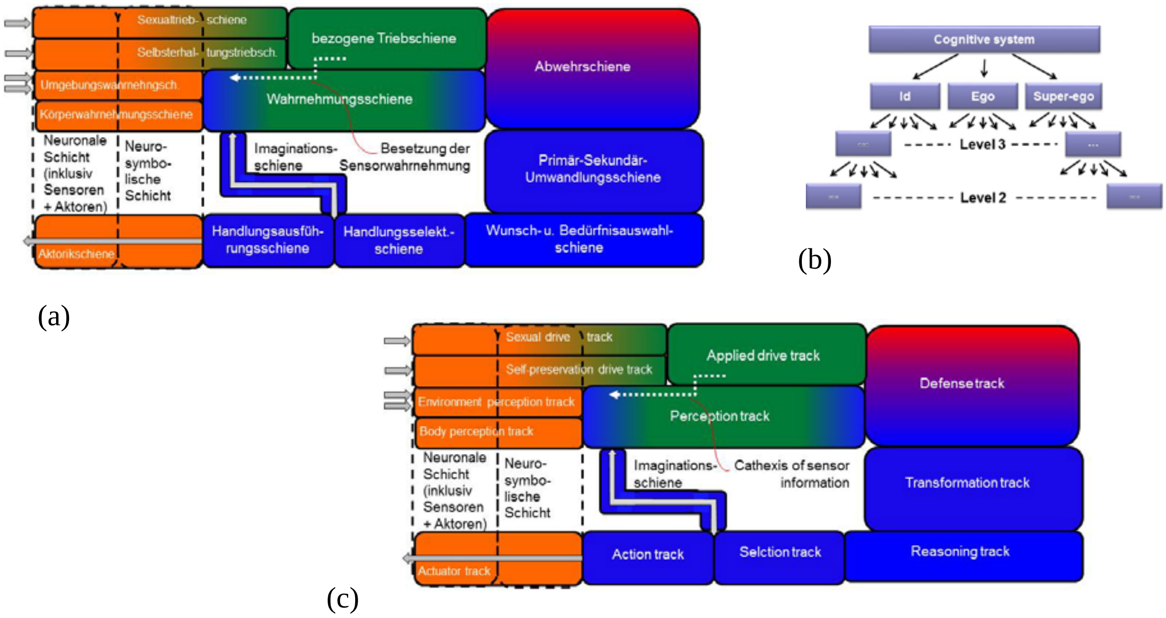

Fig. 5.11: The SiMA model at the second top-down level
(a) German terminology, (b) level structure indication, (c) English terminology

The drive contents and perception contents represent output values of the primary process. If there is no super-ego, no defense and no distinctive secondary process (e.g. as a result of massive brain lesion or in animals with insufficient numbers of neurons [Dam 99]), the psychic intensity is the exclusive measure for the ranking of action plans.

Within the secondary process, the detailed reality check results in two stages of action planning: in the first stage, the reasoning track where the most important need is chosen, the associations of the reality check are more abstract and represent social rules. In the second stage of the reality check, the action selection track, concrete actions for a particular demand are drafted in thinking[98], and

[98] CIn f. [Fre 11, 232]: “[Thinking] is essentially an experimental kind of acting”.

eventually the action which promises the greatest pleasure gain in accordance with the reality principle over the planning horizon. The following function of motor control must then implement the selected action with the physical means at its disposal.

5.6.2 Tasks of the Functions at Level 2 (of Layer 3)

In the following the sub-functions are explained, here called *tracks*.

Sexual drive track: The sexual drive track contains the drive tensions from the seeking system in Layer 1 of the brain which are subsequently separated into partial drives (oral, anal, phallic, genital) in the psyche (Layer 3) depending on sexual fixation. These drive tensions are called “libido” in psychoanalysis (see above), wherefore we differentiate the oral, anal, phallic and genital fixation of the libido. The partial drives receive objects and aims in their psychic representative, with the aim of sexuality generally being pleasure gain from or through the object.

Self-preservation track: The self-preservation track contains those drive tensions from the bodily organs which originate from homeostatic imbalance and are subsequently represented in the psychic apparatus.

Applied drive track: The drive representatives from the self-preservation and sexual tracks are formed in the applied drive track using the existing memory traces to represent psychic intensity separated into drive object, aim of drive and quota of affect. To do this, the memory is searched for actions and objects through which the generated wish can be satisfied. The organ (Layer 1) from which the drive originates is not represented in the psyche [Fre 15a, X, 216]. The goal of sexuality is generally oriented towards pleasure gain from or through the object, with every partial drive representing itself in specific aims and objects. The goal of self-preservation is the reduction of homeostatic pressure within the source organ.

The drive representatives are valuated anew using primally repressed[99] and repressed contents before personality-related (via the neutralization rate) quotas of affect are subtracted from them.

Perception track: In the perception track, data from perception are processed by being linked to subjective information from the psychic apparatus like memory traces or primally repressed and repressed contents. These results in highly diverse cathexes and interlinking of perception data via quotas of affect and associated contents. In addition, valuation takes place via emotions from a collocation of the various quotas of affect in the psychic apparatus and their modification.

Defense track: See Chapter 5.5.

Transformation track: See Chapter 5.5.

[99] See definition chapter 5.7.

Reasoning track: See Chapter 5.5.

Selection track: Possible action motions for the selected wish are developed under consideration of reality. Evaluation takes place as to which motion brings the greatest pleasure gain in regard to the reality principle, and that motion is chosen for implementation.

Action track: The eventually chosen action must be implemented with the available bodily means. This means that the psyche must translate the action choices back into chemical and physical – and thus bodily – actions via neuro-desymbolization.

Imagination track: See Chapter 5.5.

5.7 Layer 3, Level 1: Sub-Functionality, Described in Greater Detail

Level 1 is the level with the lowest degree of abstraction, meaning that the sub-functions are described in the greatest detail here. For this reason, only the reason for the further breakdown and the general tasks of the functions will be explained here, with the detailed description and tasks of the individual functions following in Chapter 7.

The SiMA model at its lowest abstraction level (level 1) is shown in Fig. 5.12 (with German terminology) and Fig. 5.13 (with English terminology). This representation differs greatly from the previous ones since it includes not only the functions themselves (numbered by Fx), but also the interfaces between them and the required memory accesses. As visible in the legend, the black arrows labeled Ix.y represent interfaces between functions that are used to transport current data. The dotted lines with arrows of various colors leading to and from functions represent interfaces which likewise exchange data, but these refer to data that are not subject to such frequent change as psychic intensity or repressed contents. Unalterable contents are modeled as so-called personality parameters I the SiMA model; they can be viewed as constant for the purpose of simulation as long as *learning*[100] is not taken into consideration in SiMA. Functions which access personality parameters are represented by heavy-bordered squares with the label DPx.

[100] From the perspective of the SiMA project, the term "learning" will require scientific reexamination, for the basis of SiMA is the functional layered model which implies that the term learning must be defined anew at least within each layer. Likewise, we know from the detailed functional description of the psyche (Layer 3) that it will presumably be necessary to define learning differently for every function in level 3. In this case, however, the definitions in the individual functions can only be made once the general description of the individual functions has been determined – which is exactly the goal of the current SiMA project. Hence the concept of learning will have to be approached after completion of this coarse specification of the psyche, and at that point the individual functions will have to be viewed mostly independently of each other.

Many functions access different aspects of the memory. These are represented as rectangles in the illustration. As learning is not taken into consideration in the current model version, these data should also be viewed as constant for the purpose of simulation.

A further term must be explained for this abstraction level: *primal repression*. Primal repression contains traumata repressed at an early age as well as early objects of drive satisfaction, and operates by providing impulses for further repressions (after-pressure) and displacing quotas of affect to opposite contents (anticathexis). Primal repression is so deeply censored/protected that it is inaccessible to analysis and can only be determined indirectly via the result of the displacements. Primal repression affects drive and perception contents, and a connection with early psychic development is assumed.

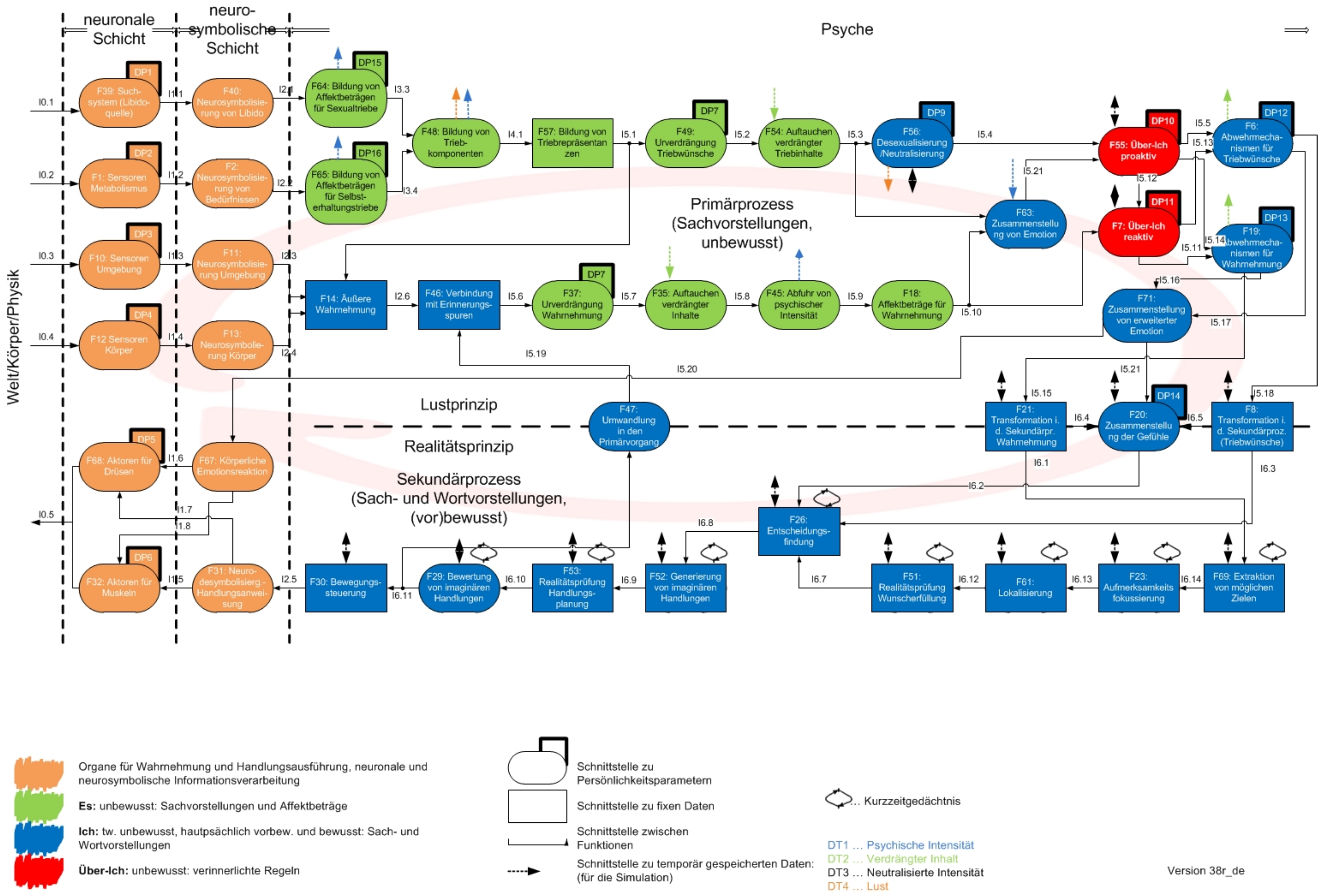

Fig. 5.12: The SiMA model at level 1; German terminology (version v38r_de)

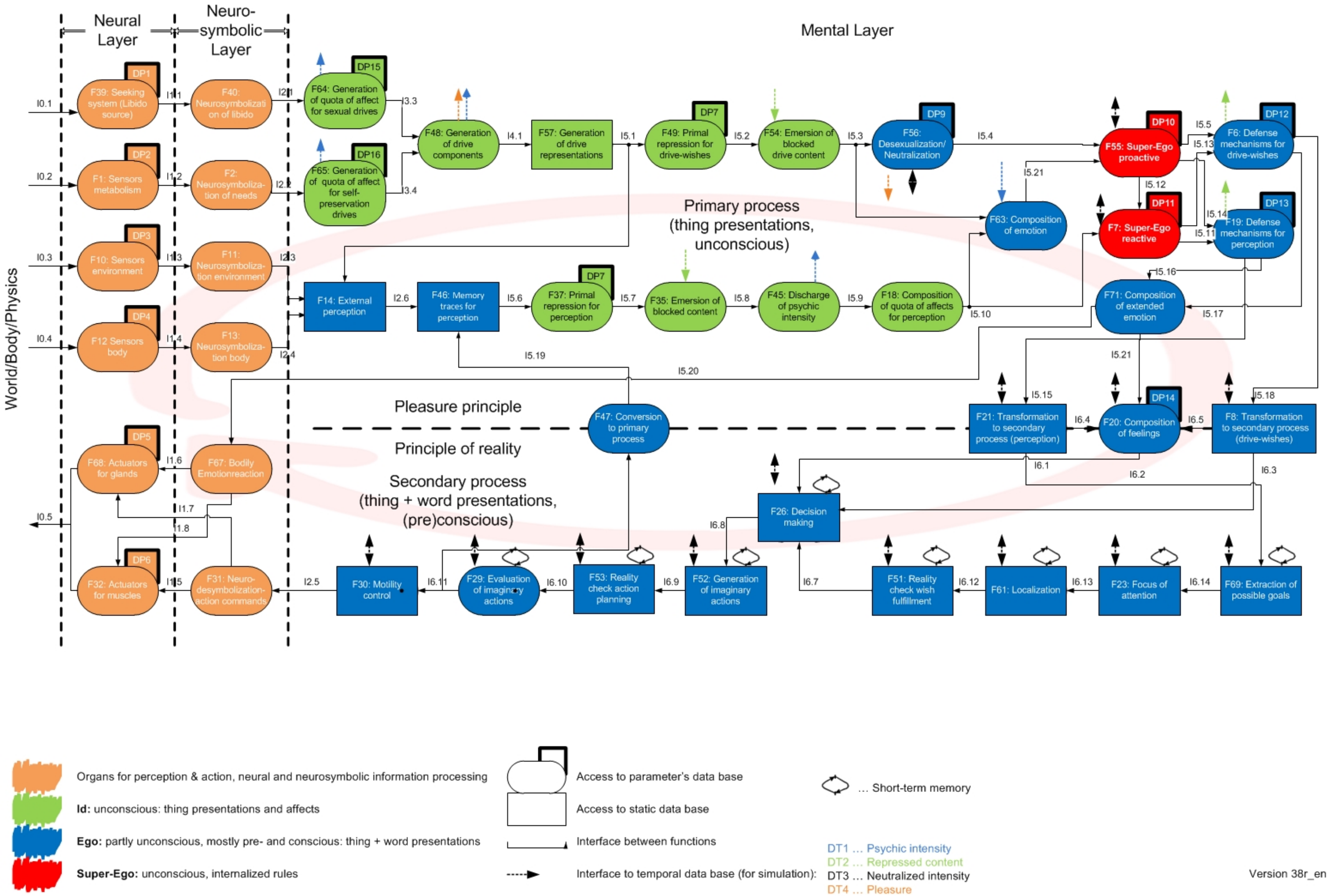

Fig. 5.13: The SiMA model at level 1; English terminology (version v38r_eng)

The function of desexualization/neutralization (F56) is central to psychic development and the functioning of a mature psyche. It takes psychic intensity from the drive representatives and makes it available to higher cognitive functions, which thus possess greater values over their valuation quotas. Neutralized psychic intensity is assigned to all functions in the secondary process, which allows e.g. the attention or the planning ability to be controlled or limited. Neutralized psychic intensity allows more complex thought processes, modulating them to some extent depending on the type of neutralization. Besides the secondary process, the defense is another consumer of neutralized psychic intensity in order to alter or repress contents.

The calculations for the quotas of affect (in F64 (generation of quotas of affect for sexual drives) and F65 (generation of quotas of affect for self-preservation drives)), the emotions (in F63 (composition of emotion) and F71 (composition of extended emotion)), and the feelings (in F20 (composition of feelings)) are explicitly separated at this level, since despite being related to one another they nevertheless represent different levels of valuation (see explanation in Fig. 5.7). In particular, emotions (= vectors) are composed of emotion scalars which are based on remembered (meaning activated by perception and fantasy) and current quotas of affect (from the drives). In the current implementation, we differentiate 16 types of quotas of affect (four self-preservation drives originating from the stomach, rectum, stamina and fluid balance, as well as four sexual partial drives – oral, anal, phallic, genital –, each with an aggressive and a libidinous component) and six emotions (anger, sadness, happiness in the sense of satiation (axiomatic term in SiMA: satiation happiness), happiness in the sense of elation (axiomatic term in SiMA: elation happiness), anxiety, and joy), as described in psychoanalytic literature (e.g. in [Jac 53, p.45ff.], which refers to [Glo 48]). These emotions have in part already been verified by measurements (in the fields of neurology and neurobiology [ST 02]. According to Panksepp – to whom [ST 02] makes reference – appropriate brain structures exist for the corresponding so-called basic emotional systems (which humans share with many mammals): the seeking system with the subsystem pleasure, anger, anxiety, and panic with the subsystem care. At the moment, five different valuation quotas are differentiated within the SiMA model (see Fig. 5.7). These include the emotions and the feelings, the latter being located in the secondary process and influenced by the underlying emotional scalars of the emotion vector as well as by the word presentations that the agent associates with them.

In future however, when further use-cases are implemented, so-called extended emotions and feelings will have to be modeled in addition, e.g. guilt, sadness in the sense of depression (axiomatic term in SiMA: depression sadness), shame, pity, revulsion, hate (with object), love (with object), and envy.

As described above, the defense track subsequently determines whether a conflict exists between the demands of the drives, the outside world and the rules of the super-ego. If a conflict is found, then an appropriate defense mechanism is initiated which must bring about a change in order to retain the ability to act in the secondary process and prevent the conflict from blocking the thought processes.[101]

There exist a number of psychoanalytically described defense mechanisms, the best-known of which is repression of undesirable[102] contents. These contents do not simply vanish, but can in fact be linked to (associated with) new contents of perception or to drive representatives when the situation changes. In this way, the repressed contents constantly attempt to "bypass the defense". The various defense mechanisms react to the intensity of the conflict in a cascading fashion: the stronger the conflict (assuming invariant ego strength), the more massive the intervention by the defense and the more primitive the applied defense mechanisms.[103]

Up to this point, the psychic contents are structured in the manner of the primary process. This means that contents are formed via thing presentation meshes, i.e. networks of individual elements associated with one another at different intensities. Cathexes (valuations) are constantly distributed across these elements, and only those elements become a psychically active content which possess a certain threshold level of cathexis. This permanent shifting of cathexis (valuation) within the primary process, which also constantly forms new psychic contents, is referred to as *displacement* and *condensation* in the terminology of psychoanalysis. The result is that no logical or temporal order between the contents exists in the primary process[104].

In the secondary process, on the other hand, the cathexes are firmly bound to contents, thus allowing their clear differentiation and demarcation and subsequently rational ordering. During transformation to the secondary process, the contents of the primary process are subjected to various rules and symbolization systems by linking word presentations from natural language (or concepts from similar symbolization systems[105]) with the contents. Natural language represents the most prominent symbolization system; it allows individual psychic contents to be processed, thought and communicated using a generally and socially accepted system of signs: temporal relations can be differentiated; topological orientation becomes possible; individual feelings are perceived. Due to

[101] Extreme examples are shocking experiences like accidents, which every person experiences somewhat differently. If the affective perceptions were not processed by the defense track in such situations, most people would not be able to act at all. A similar process, albeit in a weaker form, occurs in everyday situations.

[102] Undesirable means that these contents would yield considerable amounts of unpleasure to the ego if they were to become conscious, since they are in opposition to other demands. Hence a drive wish (e.g. sex with one's own mother) can be "undesirable" if super-ego demands (incest taboo) would be violated by its becoming conscious.

[103] Depending on the degree of intervention, defense mechanisms can be classified into more mature and more primitive mechanisms. Examples of mature mechanisms are sublimation, repression, or rationalization; examples of primitive mechanisms are denial, splitting, or projection.

[104] Cf. [Lis 09, 77].

[105] Music is an excellent example. It likewise provides a system of symbolization (in psychoanalytical language: structure) with which psychic contents (e.g. moods, wishes, relations) can be associated. The most prominent of all symbolization systems is that of natural language. It allows many of the contents fundamental within the social coexistence of our culture to be thought and communicated.

the enormous breadth of association among the data, a selection must be made by way of attention control. Attention control operates by way of *hypercathexis* through neutralized psychic intensity.

A further function at the interface between primary and secondary process is F47 (conversion to primary process), which executes the transformation from the primary to the secondary process (see Chapter 5.5. This includes the re-transformation of action plans developed in the secondary process into thing presentations, i.e. the return of fantasies into the primary process and the corresponding influence exerted on it. At the same time, this re-transformation also allows checking of the plans developed in the secondary process (in the concrete situation of perception and drive representatives) through repeated processing by the super-ego. This rechecking is necessary because the action plans remembered or newly developed in the secondary process could potentially violate super-ego rules in the current situation, thus requiring them to be checked by returning them to the primary process (and thus also to the defense).

5.8 Prospects for the Next Model Version

Besides the specification of detailed tasks in functions, or even the definition of new functions required for the implementation of further use-cases, theoretical considerations have shown that there are other aspects which must be addressed preferentially.

How should the ego-ideal be modeled? It must be placed in connection with the super-ego demands, but does not operate reactively in any given situation, rather representing social demands for the psyche that specify how one would like to be viewed or how one would ideally like to behave. Hence it provides indications for possible action planning.

However, the ego-ideal is not only responsible for action planning, but also for a stable memory of how one wishes to behave in a normal situation. The keyword in this regard is *self-representation*. It is separated into a physical and a psychic self-representation (cf. [Jac 98, p.17]). Involuntary movement patterns and the own body image are stored in the physical self-representation. The psychic self-representation contains all non-body-related concepts which (unconsciously or preconsciously/consciously) possess a self-reference. These provide a stable but nevertheless changeable image of the own self, thus e.g. allowing questions like “Who are you?” to be answered without the required information having to be collected from memory each time. A separate research project will be conducted in 2014/15 to investigate self-representations in the psychoanalytic-bionic context.[106]

[106] Project “The Self of a Robot”, sponsored by the Austrian Academy of Sciences and the Anniversary Fund of the City of Vienna, project number: 50154, project start: 01.08.2013, project end: 31.01.2015.

6. Data Structures in SiMA

Data are carriers of information. Information requires an understanding of consciousness. The differentiation between the two terms data and information is essential in SiMA because one of the goals of the SiMA project is to simulate the secondary process, which in turn begs the question of what consciousness actually is. The following chapter, however, will deal exclusively with the term data, while the relation between data and information was discussed briefly in Chapter 3.14 and will be addressed again in Chapter 8 in reference to visions for the future. This is because the topic of information has not yet been scientifically handled to any great extent within SiMA, as the prerequisites for doing so must be created first.

Since SiMA focuses exclusively on the psyche, i.e. the functional Layer 3, the data structures in the primary process will be discussed first, followed by those in the secondary process.

6.1 Data Structures of the Primary Process

The data structures in the primary process are one the one hand characterized by the data exchanged via the interface with the neurosymbolic layer: drive symbols, images, motions (all three of these are to be considered symbols) and their valuations. On the other hand, they are characterized by the valuations that exist only in the third layer, the psyche – e.g. the quotas of affect, the basic emotions, the extended emotions and the neutralized psychic intensity. These valuations (psychoanalytically: cathexes) are to be viewed as vectors.

In contrast to the data structures in the secondary process, the following features are significant:

(1) The data possess no temporal structuring, meaning that the only time-based relation existing and handled between different data elements is that of simultaneousness (or the lack thereof). The speed of a temporal progression, temporal sequence, and concepts of “earlier” and “later” are not taken into consideration.

(2) The data possess no hierarchical assignments, like in the relation between the terms pigeon and bird.

6.1.1 Data Structures in the Sense of Psychoanalysis and Their Meaningful Technical Implementation

In a layered model, the decisive data elements are defined through the interfaces. In the SiMA model, the crucial interface is that between Layer 2 and Layer 3, where the symbols, drive symbols, images and motions are transferred. One may assume that these elements are already valuated within the neurosymbolic layer during their creation, and that these valuations may be transferred along with the respective elements. This is, however, speculation which need not be investigated any further at this point since the SiMA project is focused exclusively on Layer 3, the psyche. The SiMA project is still in its beginnings and must fight to keep complexity at a manageable level; therefore, the initial assumption is that drive symbols, images and motions are transferred at the interface between Layer 2 and Layer 3 without any valuations.

The drive symbols, images and motions can be viewed as atomic elements associated with one another. An element, image or motion is called a *thing presentation mesh (TPM)*, while a drive symbol is referred to as a *drive mesh (DM)*. Initial developments have shown that these networks require massive amounts of computing power since the type of information must be queried for each element. For this reason, the *thing presentation (TP)* was defined in addition, resulting in a data structure as per Fig. 6.1. A *thing presentation mesh* cannot exist without a *thing presentation*, nor vice versa.

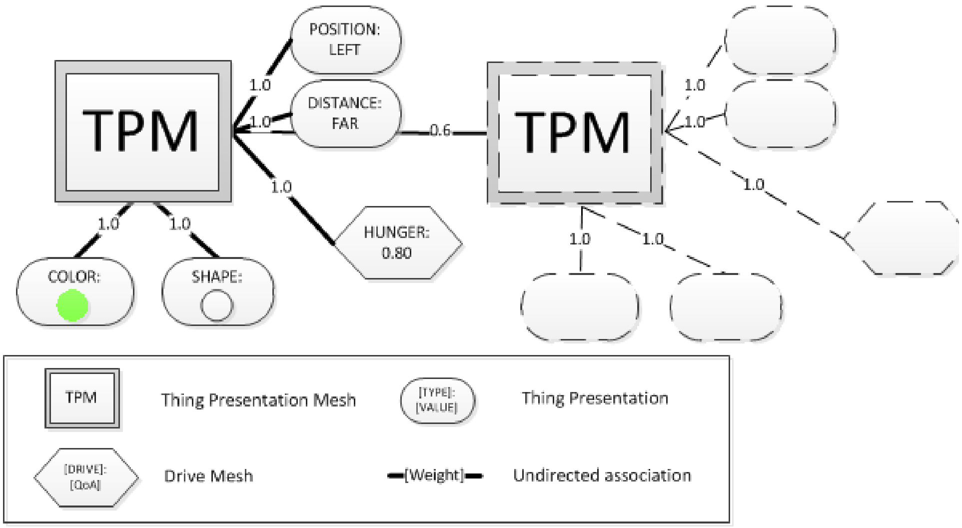

Fig. 6.1: Data structure of the thing presentation mesh (TPM) of the primary process

6.1.2 Data Elements of the Primary Process

Fig. 6.1 illustrates the relationship between *thing presentation (TP)* and *thing presentation mesh (TPM)*. The meaning of these two terms is explained in the following

Thing Presentation (TP)

A *thing presentation* is the representative of a thing. It is valuated through a quota of affect. Thing presentations are to be viewed as atomic elements and not connected. They can merely represent elemental concepts such as shapes, colors, sounds, smells, flavors, body information, homeostatic information or automated movement sequences [Zei 10]. Thus in Fig. 6.1, a *thing presentation* is an attribute of a *thing presentation mesh*.

Thing Presentation Mesh (TPM)

A *thing presentation mesh* is assembled from *thing presentations* and/or other *thing presentation meshes*.

The thing presentation mesh consists of associations with other thing presentation meshes or thing presentations, with a type and an identifier assigned to the aggregation. If a thing presentation mesh describes an image, then the type is IMAGE and the identifier is the name of the image. By definition, thing presentations and thing presentation meshes cannot stand alone. They receive a meaning only by being associated with one another.

Drive symbols, images and motions are always associated with drive symbols, images and motions as indicated in Fig. 6.1.

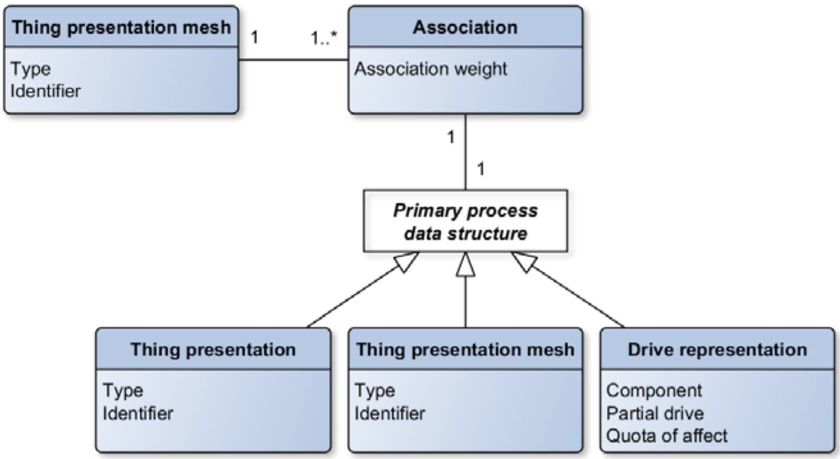

Fig. 6.2: Class diagram[107] of the associations of a thing presentation mesh

Fig. 6.2 shows the connections of thing presentation meshes with other data elements via associations in a class diagram. It is important to note that everything presentation mesh must possess at least one association, but each association is assigned to exactly one thing presentation mesh.

Drive Representative – Drive Mesh (DM)

[107] The class diagram uses a format similar to UML which is explained in the appendix.

The drive mesh specifies to what degree a thing presentation mesh associated with it is capable of satisfying the drive represented by it. A drive mesh can exist independently of a thing presentation mesh, in which case it represents a need of the body. This means that a drive mesh has two tasks: one the one hand it acts as a pure drive representative, while on the other it serves to valuate the drive object associated with it, i.e. the thing presentation mesh of the object with which the drive can be satisfied. Within perception, drive meshes are defined as attributes of a thing presentation mesh (e.g. a Schnitzel can be highly valuated due to a high drive tension).

The drive mesh is defined by a *component*, a *partial drive*, and a *quota of affect*. *Component* refers to the aggressive or libidinous component of a drive. We differentiate *sexual drives* and *self-preservation drives*. The representatives of the sexual drives are split into four *partial drives*[108]: *anal*, *oral*, *phallic*, and *genital*. The *quota of affect* defines the quantitative need of a drive to be satisfied.

The data structure of the drive mesh is defined by a *drive source*, a *drive component*, a *partial drive*, an *aim of drive*, and a *drive object* together with a *quota of affect*. Currently, only the drive component, the partial drive and the quota of affect are stored directly in the drive mesh, with the drive source, aim of drive and drive object linked with the drive mesh via associations.

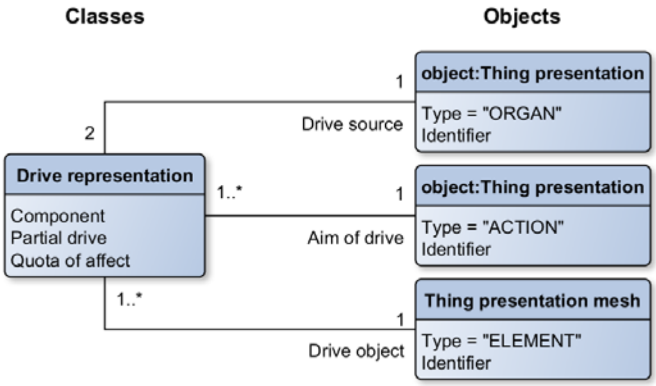

Fig. 6.3: Class and object diagram of a drive mesh

Fig. 6.3 shows the connections with the drive mesh in a class diagram with object diagram elements. Every drive mesh has exactly one drive source, one drive object and one aim of drive associated with it, but any number of drive meshes can be associated with any one drive object and any one aim of drive. Each drive source has exactly two drive meshes associated with it which differ in regard to their drive component[109], thus separating the aggressive and libidinous components of a drive.

Association in the Primary Process

[108] Partial drives are only defined for sexual drives in psychoanalysis.

[109] For example: In order to represent the aggressive and libidinous components of the hunger drive, the drive source *stomach* is associated with two drive meshes, one with the drive component aggressive, the other with the drive component libidinous.

The associations in the primary process connect two data elements with one another: a thing presentation mesh with another thing presentation mesh, a thing presentation mesh with a thing presentation, or a thing presentation mesh with a drive mesh. According to the theories of psychoanalysis, the associations in the primary process consist of the connection between two things and the strength of that connection. The associations are not directional.

6.1.3 Symbolic Representations

Symbols (drive symbols, images, motions) are implemented on the basis of the elements described in Section 6.1.2. They are generated in the second functional layer (the neurosymbolic layer) out of sensor data from the first functional layer.

Drive Symbol

The symbolic representation of drives occurs entirely through the abovementioned drive meshes.

Image

An image is a symbol and thus a thing presentation mesh of connected elements represented in the psyche. Fig. 6.4 shows an example of the structure of an image, which in the example consists of two elements which likewise represent images.

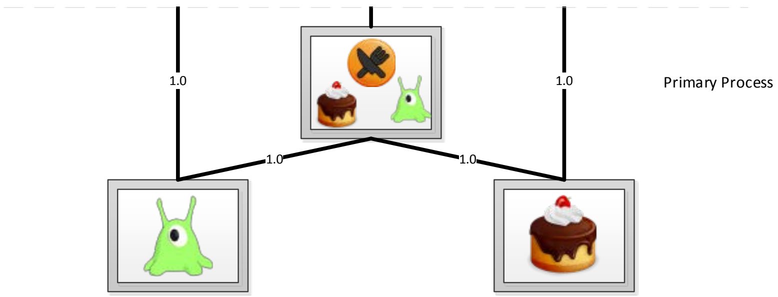

Fig. 6.4: Association of images in the primary process

The connections leading upwards out of the illustration are intended to indicate that these images can possess other valuated associations with other symbolic representations in the primary or secondary process.

An image (a visual, auditory, olfactory, gustatory or tactile image) is to be understood as a snapshot of a scene at a certain point in time.

Perception-Image: The perception-image should be understood as a snapshot of a scene[110] coming in through the perception track at a certain point in time, with scene referring to the actual process of

[110] The terms *scene* and *motion* are defined differently in the SiMA project. The term motionis defined in the following. The term scene refers in general terms to a sequence of outside events.

events in the outside world.[111] The perception-image consists of the elements perceived at a certain point in time.

Memorized Image: A memorized image is an image originating from the agent's memory. This represents a memory trace in psychoanalytical terminology. A memorized image is an image that an agent will not forget.[112]

Template Image: A template image is a generalization of similar images. They are formed via a class holding common attributes distilled from the similar images.

Motion[113]

A motion is a symbol like an image and represents a sequence of events over a short period of time. It can be associated with other motions and images. As it represents a symbol, it can be formed in the functional Layer 2 and processed in the primary and secondary processes. This is contrasted by the act, which only appears in the secondary process and is therefore exclusively defined through conscious events.

6.1.4 Valuations in the Primary Process

The 5 valuations introduced in SiMA are specified in Chapter 5 (see Fig. 5.7). Their respective data structures differ from each other.

Quota of Affect

The *quota of affect* is the first valuation of drive wishes in the psyche. It is part of the drive mesh and represented by a numerical value between 0 and 1.

Basic Emotion

The basic emotions are calculated from the *quotas of affect*. The following scalars with values between 0 and 1 form an emotion vector[114]:

1. the aggregation of all quotas of affect,
2. the current pleasure,
3. the aggregation of quotas of affect of all libidinous drive components,
4. the aggregation of quotas of affect of all aggressive drive components.

---

[111] This makes it obvious that the perceived image always represents a reproduction of reality modified in Layers 1 and 2.

[112] That it is not possible to forget is a working hypothesis and has to be differentiated later on.

[113] In principle, different types will have to be differentiated for motions like they are for images. For the only use case hitherto implemented, however, this is not required; therefore, the term has not been developed in more detail as of yet.

[114] The basic emotion vector and the extended emotion vector possess the same structure; thus they can be summed up as emotion vector for simplicity.

Depending on the dominance of the scalars in this vector, different basic emotions are represented. Six basic emotions are currently implemented:

1. anxiety (Angst),
2. anger (Wut),
3. love-elation (Glücklichkeit-Hochgefühl),
4. love-saturation (Glücklichkeit-Sättigung),
5. mourning (Trauer) and
6. joy (Freude).

Extended Emotion

The basic emotions can be extended in the course of the defense mechanisms, thus creating *extended emotions*. For example, association of the strength of a conflict with the basic emotion *anger* in the defense results in the extended emotion *guilt*.

Neutralized Psychic Intensity

A configurable percentage of the quotas of affect is used as neutralized psychic intensity. It is available to functions of the ego in order to – in addition to the functions of the id – be able conduct cathexes, for example in attention control. Furthermore, neutralized psychic intensity regulates the extent of the respective function, e.g. the depth of thinking, planning horizon, etc. The reason for this is that secondary-process-based ego-functions increasingly come into effect in the mature psyche (according to Freud's therapeutic goal: "Where Id was, Ego shall be." [Fre 32, p.86]). The rest of the psychic intensity remains in the drive cathexes conducted by the primary process.

6.2 Data Structures of the Secondary Process

The data structures of the secondary process are based on those of the primary process and cannot be viewed as completely detached from them. A differentiation must be made between the principal data elements of the secondary process and the underlying symbolic representations.

6.2.1 Data Elements of the Secondary Process

As in the primary process, the smallest atomic element within the secondary process is once more differentiated for technical reasons into a word presentation and a word presentation mesh. Fig. 6.5 (example of a word presentation mesh of the secondary process contrasted with a thing presentation mesh of the primary process) and Fig. 6.6 (class diagram of a word presentation mesh) serve to clearly define the concept of the word presentation mesh.

Word Presentation (WP)

Word presentations represent things/objects within a language system existing in the psyche. They consist of the thing presentations of the physical representatives of the word in the language which designates the thing/object (sound image, reading image, writing image, etc.) and are associated with at least one thing presentation representing the thing/object. The word presentation can be understood as an analogy in the secondary process to the thing presentation in the primary process, with the thing presentation associated with a word in the respective language.

Word Presentation Mesh (WPM)

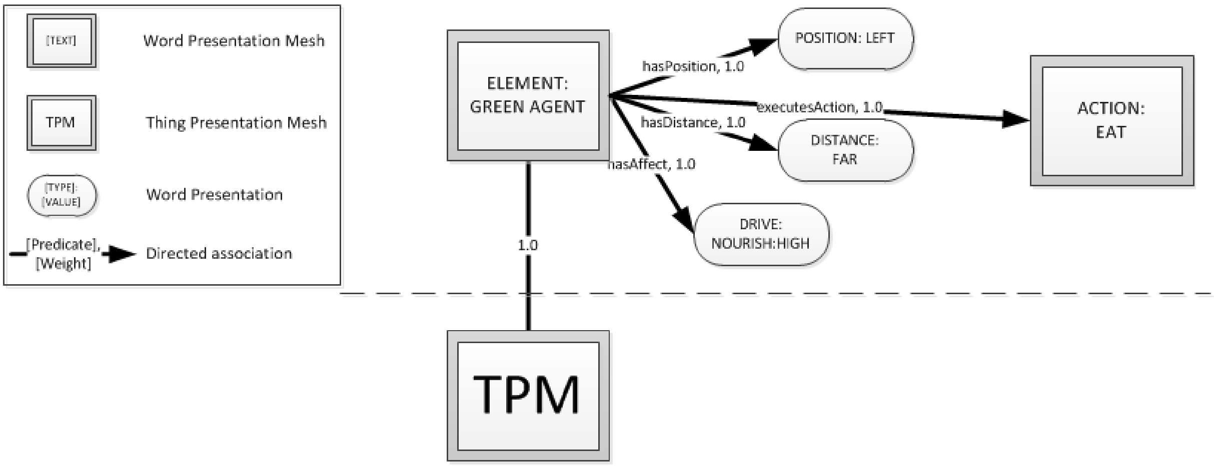

Fig. 6.5: Example of a word presentation mesh of the secondary process contrasted with a thing presentation mesh of the primary process

The *word presentation mesh* is the analogous data structure in the secondary process to the thing presentation mesh in the primary process. The word presentation mesh is the representation in a language system of a thing represented by a thing presentation mesh in the psyche. Fig. 6.5 shows the equivalent illustration of a word presentation mesh as compared to a thing presentation mesh. In the example, the thing presentation mesh for a green agent is associated with the appellative word presentation mesh GREEN AGENT.

Fig. 6.6 shows a class diagram of the connections of word presentation meshes with other word presentation meshes or word presentations via associations. Every word presentation mesh must be associated with at least one data element (which must be either a word presentation or another word presentation mesh). Furthermore, every word presentation mesh must be associated with at least one thing presentation mesh.

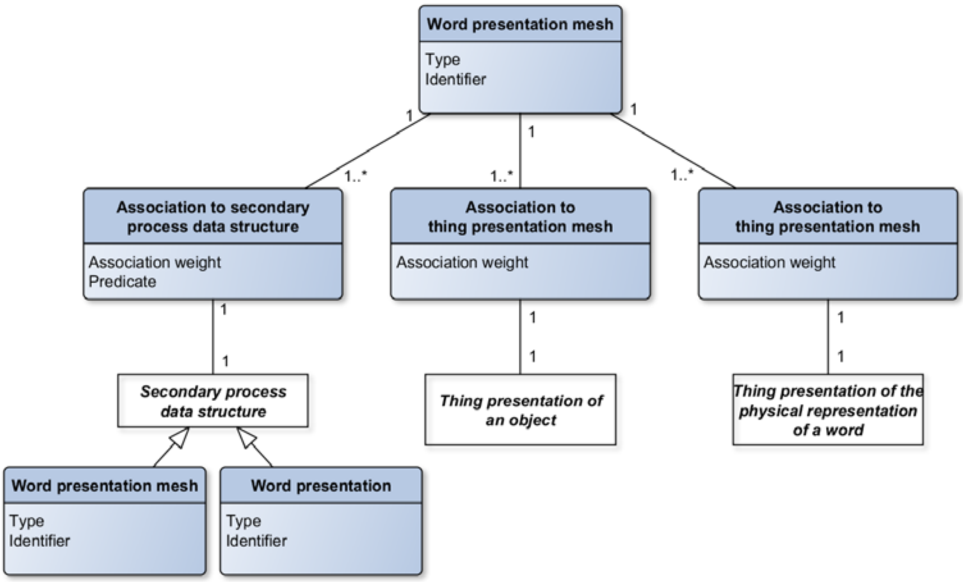

Fig. 6.6: Class diagram of a word presentation mesh

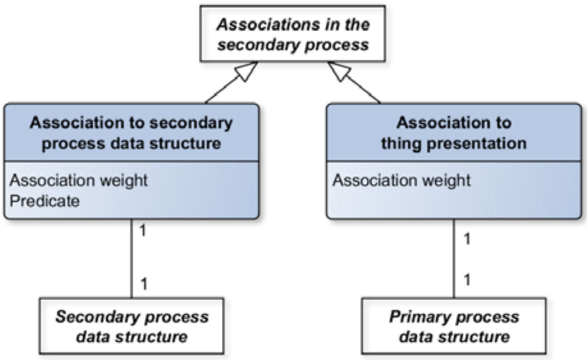

Fig. 6.7: Class diagram of the association types in the secondary process

Associations in the Secondary Process

There are two tapes of associations in the secondary process: the associations between word presentation meshes and other word presentation meshes or word presentations, and the associations between word presentation meshes and the corresponding thing presentation meshes. Associations in the secondary process are directional, meaning the elements connected by them have clearly defined roles in regard to the association, e.g. object on the one hand and class of the object on the other (example: Harold is a bird; with "is a" being the association).

6.2.2 Symbolic Representations in the Secondary Process

Several complex data structures of symbolic representations exist in the secondary process, and they are based on the data structures of the primary process. They form the prerequisite for conscious procedures. Like for the *image*, further differentiation of the term *motion* will be foregone in this report since the only hitherto implemented use-case does not require such differentiation. This will have to occur for the use-cases to follow which make use of motions; while new insights are not expected from these additional use-cases, they will nevertheless allow more complex acts to be simulated.

Labeled Image

An image connected with a word presentation mesh designating that image is referred to as a *labeled image*. In the example following Fig. 6.8, three labeled images (1a and 1b, 2a and 2b, 3a and 3b in Fig. 6.8) are assembled from images[115] from the primary process and the corresponding word presentation from the secondary process (see also Fig. 6.4). The labeled image 1a-1b represents an agent, while the labeled image 2a-2b represents a CAKE. The labeled image 3a-3b represents the situation of an agent eating a CAKE. Hence images representing objects are part of a snapshot and are connected with the situation via the association with the attribute *hasPart*.

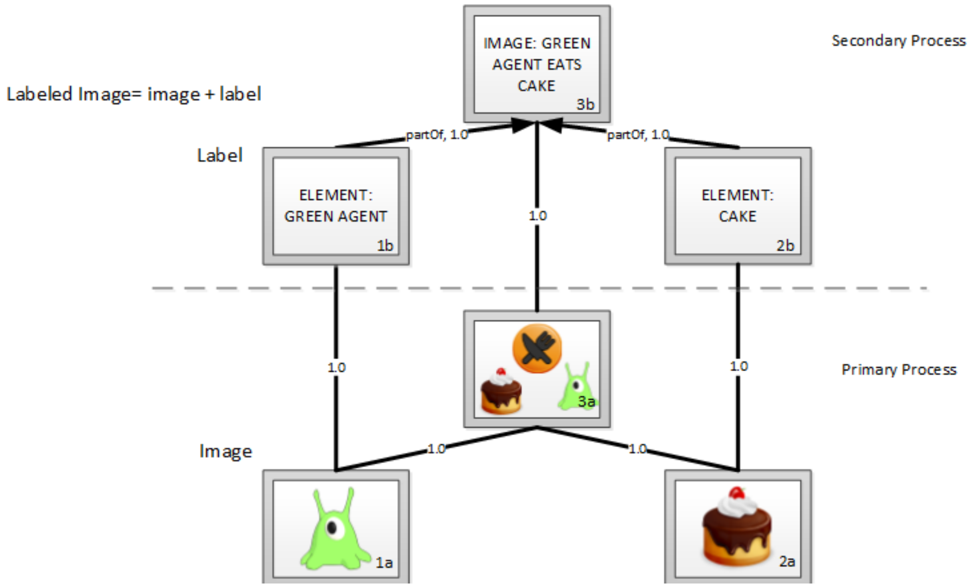

Fig. 6.8: Example of a labeled image

Act

An *act* is a causally and logically traceable sequence of events which is assembled from images and motions and can contain other acts. It has one or more goals and may optionally include certain places (landmarks) relevant to the recognition of a situation. Goals and landmarks are likewise defined via images. Acts are conscious planning sequences and can thus only occur in the secondary process. Solms explains that prior to becoming conscious, such acts have already been played

[115] The examples are confined to images, but the same applies to motions; since images and motions both represent symbols, they can be linked in the same way.

through (computer engineers say: simulated) multiple times in parallel [Die 09.2]. Hence they are sequences characterized by *semantic* associations.

Fig. 6.9 shows an example of the structure of an act in its relation to the primary process. The act describes an event named *Dinner for One* in an agent's memory, in which the agent sees another agent, the GREEN AGENT[116], eating a cake. In this example, each association in the secondary process possesses a weight of 1.0[117] and one of the attributes *hasSuper* or *hasNext*. These represent the logical connections. Different associations between the images based on *similarity* and *simultaneousness* exist in the primary process, and their weights are a measure of these two values.

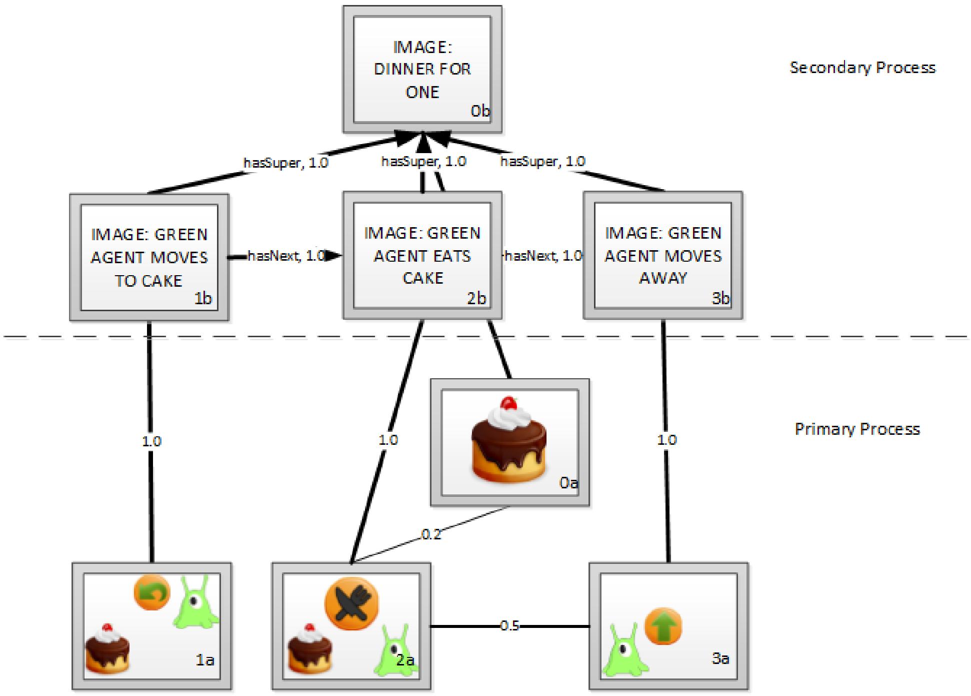

Fig. 6.9: Example of an act in the primary and secondary process

The generalized labeled image, consisting of the thing presentation 0a and the word presentation 0b (IMAGE:DINNER FOR ONE), summarizes the entire event. The sequence begins with a labeled image in which the observed GREEN AGENT is moving towards a CAKE. The labeled image consists of the thing presentation 1a and the word presentation 1b (IMAGE: GREEN AGENT MOVES TO CAKE). Via the association in the secondary process, with the attribute *hasNext*, the next labeled image, consisting of 2a and 2b (IMAGE: GREEN AGENT EATS CAKE), is reached. In the final labeled image, consisting of 3a and 3b (IMAGE: GREEN AGENT MOVES AWAY),

[116] The capital letters denote that these terms have been adopted into the simulation package as they stand here.

[117] Valuated semantics will be introduced in a future step; therefore only the association strength 1.0 currently exists in the example.

the GREEN AGENT withdraws from the CAKE. Each event in the act is connected to the generalized labeled image via an association with the attribute *hasSuper*[118].

Goal

The goal is a word presentation mesh which additionally transports contents from a drive representative. It is derived from a drive mesh of the primary process for the secondary process and thus appears as the goal of a drive wish, i.e. as the representation of a need of the psyche to be satisfied. Alternatively, the goal can be associated with an image from perception, in which case it represents the possibility to satisfy a drive wish through the object represented by this image.

Word Presentation Sequence (WPS)

Word presentation sequences are special word presentation meshes for representing phrases and sentences of natural language in the psyche. The possibility of differentiating before and after in the secondary process forms the basis for the order of word presentation meshes in word presentation sequences: each element of the sequence has an antecessor and a successor.

6.2.3 Valuation Quota in the Secondary Process, the Feeling

In contrast to the primary process, in which 4 different valuation quotas are differentiated, only a single valuation quota is used in the secondary process in SiMA as per Damasio [Dam 97, p.262]: the *feeling*. The feeling is a valuation quota (vector) for objects and decision-making in the secondary process, like the sequence of an act.

6.3 Memory – Storage

Human memory is still a highly topical field of research in many areas of science. There are many hypotheses, but precious few of them are provable in natural scientific terms. There are some phenomena which have been recognized, but we usually do not know with any certainty what is going on neurologically. Therefore, the SiMA project has reduced its requirements to the most basic principles of memory. In its bottommost layer, every *memory* is based on *storage* of some kind, as will be discussed further in the following.

In contrast to human memory, an additional *cyclic storage* must be defined for the SiMA model which has no counterpart in a biological body.

[118] *hasSuper*: the name designates the association. The component *has* indicates that it is an association denominator, while *super* indicates a generalizing association.

6.3.1 Memory Model

As per Fig. 5.12, the SiMA functions are complex units in which data are manipulated. No memory or storage is taken into consideration within these functions, since the storage in itself represents a complex process. On the one hand the stored data must be read/write accessible by multiple functions at the same time, and on the other hand access to the memory/storage can only be explained via a layered model in analog to the layered functional model described in Chapter 5.

Layers of the Memory Model

It makes the most sense to imagine a three-dimensional model as in Fig. 6.10. At the front side can be seen the layered model as in Fig. 5.3. The vertical surface on the side of the model shows the layers of the memory model. This illustrates that we assume a joint functional layer (Layer 3, the psyche) as in Fig. 5.3 which has access to the storage in the hardware (memory model layer 1) via the access control in memory model layer 2. This also entails the definition of the terms *memory* and *storage*. *Storage* refers to the units of hardware, i.e. the bottommost layer shown on the right-hand surface in Fig. 6.10, while the entire right-hand vertical surface forms the model for the *memory*, thus including the storage access control layer.

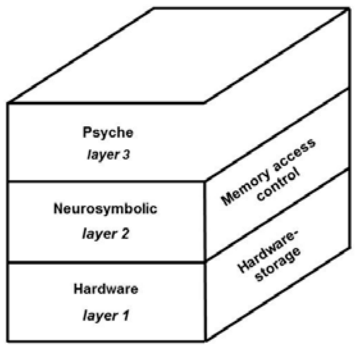

Fig. 6.10: Layered model of the memory

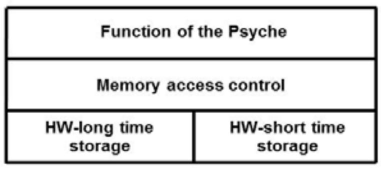

Fig. 6.11: 2D model of the layered memory model

The right-hand vertical surface, i.e. the model for the memory from Fig. 6.10 is shown in more detail as a 2-dimensional image in Fig. 6.11. It illustrates that the bottommost layer 1 of the memory model, the hardware storage layer, must be further differentiated into an area for *long-term storage* and an area for *short-term storage*. This reflects only the two types of memory biologically required to explain the fundamental memory phenomena relevant to SiMA.

Long-Term Storage

In humans, long-term storage can be visualized neurologically as the creation of synapses. Such synaptic connections generally never dissipate under normal circumstances unless they are broken (by dementia, tumors, etc.) [Die 12] or if they are never used/activated. Once data are stored in this way, they cannot be lost suddenly. The basic hypothesis in SiMA – as is likewise the case in psychoanalysis[119] – is that forgetting of information in the long-term storage is not considered, also since SiMA by definition assumes a healthy model not subject to damage.

In a computer, long-term storage (the bottommost layer in the memory model) corresponds electronically to ROM.

Precisely which data/pieces of information are stored in long-term storage shall not be discussed here for reasons of brevity; it can however be stated that all data/pieces of information that a human does not forget, like *memories, personality parameters,* etc. are included.

Short-Term Sorage

The model that obviously suggests itself for human short-term storage is the positive feedback of an interneuron as examined and simulated in detail in [Lan 76]. In this process, a neuron inhibited by an inhibitory interneuron can be returned to its original state by an excitatory interneuron. Due to this model concept, the SiMA project assumes that data can be stored for up to 3 seconds[120], after which the data are lost for good unless the storage process is refreshed.

Various data are stored in short-term storage; they are data required briefly for the psychic functions, e.g. localization or object data, which are forgotten if they are not refreshed or transferred to long-term storage.

6.3.2 Cyclic Storage

From the point of view of information theory of computer engineering, the brain is an *asynchronous, parallel* information system, meaning a system that does not operate based on a cycle. Such an asynchronous system has a number of advantages. For example, the asynchronism allows higher reaction speeds than could be achieved in a synchronous system. The *parallel* information flow in the brain likewise results in an increase in reaction speed since the functions operating in parallel can make their results available nearly simultaneously. Both of these facts pose great challenges in regard to simulation, however.

The desire to develop asynchronous computers (and thus imitate the brain), has led to a multitude of scientific investigations and experiments, but the end results have invariably been modest at best. A

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[119] Cf. [Fre 14, 126]: “The forgetting of impressions, scenes, experiences generally is reduced to them being ‘locked out’.” … “Especially in the manifold forms of compulsion neurosis, forgetting is usually restricted to the dissolution of connections, the misjudgment of sequences, the isolation of memories.”

[120] This duration is chosen arbitrarily, since no more precise data was could be found in literature. Not much time was spent deliberating the time phenomenon, however, as an incorrect assumption will quickly become apparent in the evaluation of the use cases.

decisive breakthrough in this field remains a desideratum. As the focus in the SiMA project is on the model of the psyche, its simulation uses a synchronous model in which the data coming from the input (Fig. 5.10) is channeled through the individual functions successively and is eventually made available to the outside world via the actuator output (see Chapter 5.5 and Fig. 5.10 in particular). According to the theories of control engineering, the duration of a single cycle must be significantly shorter (by a factor of 10) than the shortest time constants in the functions Fx of the psyche in Fig. 5.12.[121] In other words, the cycle time must not have any effect on the behavior of the agent, i.e. on the results of the functions in Fig. 5.12. For individual functions to recognize what was processed before them, however, it is necessary for an additional storage to be available to them which has nothing to do with the SiMA model directly. These data are stored in the *cyclic storage*, which is independent of the long-term and short-term storage areas and must not be brought into connection with them.

The following cyclic storage areas have been defined for the SiMA project (see also Fig. 5.12):

- DT1: psychic intensity
- DT2: repressed contents
- DT3: neutralized psychic intensity
- DT4: pleasure.

[121] This means that the cyclic storage must react 10 times as quickly as the short-term memory. Assuming 3 seconds for the short-term memory, each individual cycle would have to be completed in no more than 0.3 seconds of real time. For the purposes of simulation, these time spans must be appropriately lengthened.

7. Functional Description F1 to F66 at Level 1 (of Layer 3)

In contrast to the previous subsections of Chapter 5, Section 5.7 does not discuss the individual functions at level 1, as such a description requires knowledge of contents presented in detail only in Chapter 6. The following Chapter 7 will now describe all functions in the SiMA model at the lowest level of abstraction, level 1. Further analysis (i.e. further breaking down according to the top-down design method) and synthesis of individual functions must however remain in the realm of dissertations created within the SiMA project.

As explained in Chapter 3, the hardware layer and the neurosymbolic layer (Layer 2 and Layer 3) have no significance for the development of Layer 3 according to the information theory of the layered model and are thus implemented as dummies in the simulation.

The following elucidations are based on the scheme in Fig. 7.1, which is derived from Fig. 5.11 (b). All 45 functions[122] will now be plotted into this image (see e.g. Fig. 7.2).

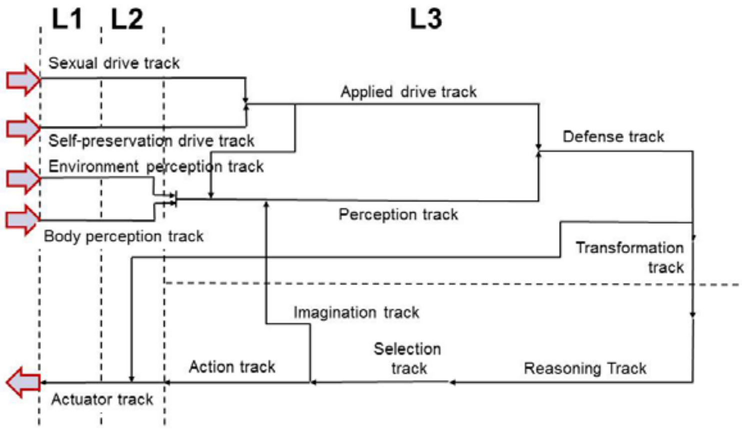

Fig. 7.1: Basic structure for Chapter 7 derived from Fig. 5.11 (b)
For better visualization, Fig. 7.1 is simplified in comparison with Fig. 5.11 (b)

[122] The numbering of the functions reflects the development of the model over time; they will eventually be renumbered in a consistent fashion at an appropriate time. The same applies to the interfaces between the functions.

As explained in Section 5.2, the top down process requires Layer 3, the topmost layer, to be modeled before approaching Layers 2 and 1. The current SiMA project therefore implements only a single function per Layer 1 or 2 for each of the sensor tracks and the single actuator track in order to formulate the respective specific task per track and layer in the most abstract manner possible. In terms of the simulation, they are treated as dummies, meaning that the generation of symbols, images and motions for Layer 3 is considered a given and the appropriate output values from Layer 3 to Layer 2 are considered the final output values of the simulation model. This also means that direct feedback loops in Layers 1 and 2 like reflex arcs (e.g. the knee reflex or the testicular reflex) are disregarded. These two lower layers will need to be developed for the SiMA model to eventually be integrated into an actual robot.

7.1 Sexual Drive Track

The sexual drive track[123] consists of 3 functions in all layers (1, 2 and 3, see Fig. 7.2).

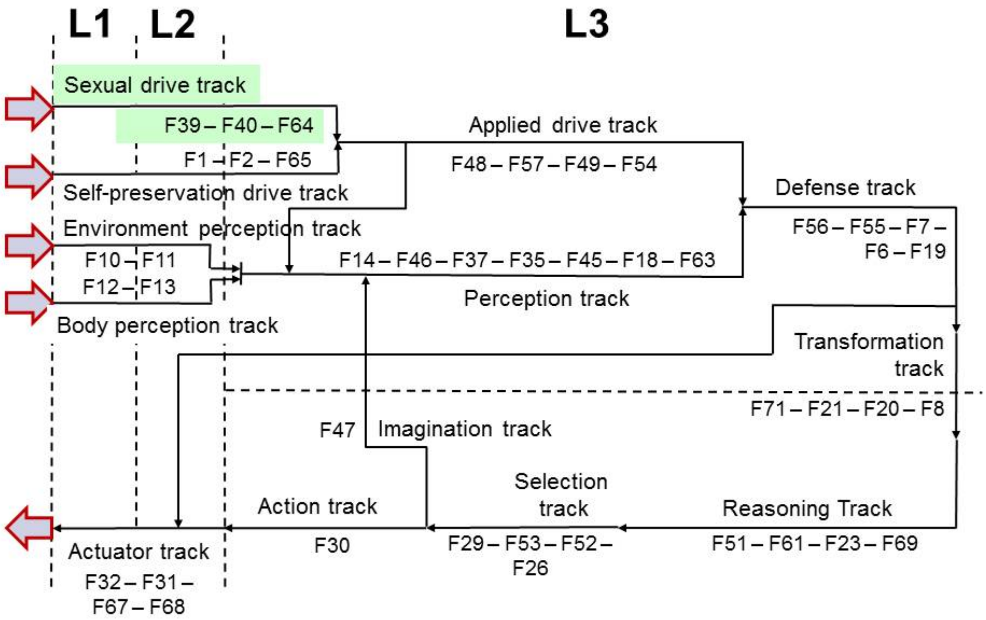

Fig. 7.2: Sexual drive track

[123] The term “drive” is a term from the functional Layer 1; only representations of drives exist in Layer 3. Thus speaking strictly axiomatically, this track should be called the drive representation track. In general usage, however, one nevertheless speaks only of drives, a fact which prompted the authors to neglect the differentiation as long as there is no danger of confusion and the terms are not used to derive any formalizations.

7.1.1 Function F39: Seeking System (Libido Source)

This function F39 is part of the sexual drive track (Fig. 7.2) and possesses the following interfaces[124]:

- Input I0.1
- Output I1.1
- Personality parameter DP1

General Functional Description

Function F39 exclusively describes hardware in Layer 1, i.e. the function of the sensors and the information processing and transfer[125] (interface) to Layer 2.

According to Freud, the source of every drive is the body with its tension states. In F39 (seeking system (libido source)), such tension states are registered for the sexual drive. Freud calls the drive "a continually flowing, inner-somatic stimulus source" [Fre 05, 67]. In Layer 3, the psyche, this parameter is therefore referred to as the drive wish since it only represents the drive. The intensity is represented in quotas of affect which form the basis for the multi-level valuation system (psychoanalytically: cathexis system) in the psyche. In effect, all symbols, images and motions are constantly and repeatedly being valuated.

The source/cause for imbalance of the sexual drives lies in imbalance of the sexually motivated homeostasis parameters on the one hand, and in a permanent buildup of libido on the other. This results in an increase in sexual psychic intensity within the psychic apparatus. Its progression is influenced by sexually motivated homeostasis parameters (e.g. hormones). The amount of produced and free sexual hormones can be specified on a per-gender basis.

The inputs to this module are a continuous influx of libido from the body as well as signals from the erogenous zones. Both types of information are passed on to the module F2.

Input[126]

I0.1: Physical sensor input values representing the sexual tension sent from appropriate hormone sensors, which eventually lead to corresponding symbols in I2.1 in F40 in Layer 2 (neurosymbolization).

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[124] Ix.y: I stands for *interface*.

[125] As misunderstandings frequently arise at this point, it must be emphasized that according to information theory of computer engineering Layer 1 (hardware) describes the entire electrical information function of the model, starting with the sensors and ending at the neurosymbolic interface. Physical body parameters of the agent itself, its physical energy conversions etc. are not described.

[126] These input values of Layer 1 currently only play a quantitative role in the SiMA simulation, allowing determination of where the input data in Layer 3 originate from. The same applies to the output values of Layer 1 and the input and output values of Layer 2.

Output

I1.1: Electrical output parameters derived from I0.1

Interface to Personality Parameter DP1

Personality-related bodily parameters regarding the generation of various hormones; level of hormone release and resulting libido

7.1.2 Function F40: Neurosymbolization of Libido

This function F40 is part of the sexual drive track (Fig. 7.2) and possesses the following interfaces:

- Input I1.1
- Output I2.1

General Functional Description

The electrical data coming in via interface I1.1 are sensor data from hormone glands. Layer 2 is an abstract layer above the hardware, its only task being to transform the electrical signals into micro-neurosymbols, then into neurosymbols (see Section 2.8) and finally into symbols[127] which are then provided to Layer 3. The interface parameters between Layer 1 and Layer 2 (input for F40) I1.1 are therefore electrical parameters, while the interface parameters between Layer 2 and Layer 3 (output for F40) I2.1 are symbols.

Input

I1.1: Electrical output parameters

Output

I2.1: Symbolization of libido and association with the corresponding erogenous zone (oral, anal, genital, phallic)
The values of the transmitted symbols represent the total increase in sexual tension (libido). They are multimodal symbols which represent the sexual drive in their totality (= symbolization of hormone values in connection with the erogenous zones).

7.1.3 Function F64: Partial Sexual Drives

Function F64 is part of the sexual drive track (Fig. 7.3). It is located in Layer 3 and possesses the following interfaces:

- Input I2.1
- Output I3.3

[127] This 3-layer model within Layer 2 has been discussed in principle with regard to the feasibility of its modeling in the dissertation [Vel 08], but has not yet implemented in detail.

- Output psychic intensity DT1
- Personality parameter DP15
- An interface to the data in the cyclic storage

General functional description

In function F65, drive components are formed from the bodily sexual drive tension and represented in Layer 3, the psyche. Each of these components is a representation of the bodily need for pleasure related to a certain erogenous zone. A drive representative is represented via 3 contents and the quota of affect:

- The source of the drive representative (inner-somatic sources like an organ),
- The aim of the drive representative (generally satisfaction, specifically the action through which satisfaction can be achieved),
- The object of the drive representative (on which or through which the aim can be achieved) and
- The quota of affect (a quantification of the drive tension).

The sexual drives remain separated into libidinous and aggressive components. As stipulated in psychoanalysis, the body continually produces the same constant amount of libido.[128] Until this libido is discharged, it is continuously separated into individual partial drives (anal, oral, genital, phallic) and thus increases the cathexes (valuation) of the corresponding psychic contents.

The following sexual drives exist, each related to the corresponding erogenous zone:

- Oral[129],
- Anal[130],
- Genital[131] and
- Phallic[132].

Undischarged[133] libido is represented in the body via the erogenous zones, and in analogy to the generation of self-preservation drives (see Section 5.6), partial drives are formed with the contents *drive source*, *aim of drive*, *drive object* and *quota of affect*.

The signals from the erogenous zones report stimulation of the zones to F65. The valuations (psychoanalytically speaking: cathexes) effected by the corresponding sexual drive in the drive representative are decreased according to the stimulus.

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[128] Cf. [Fre 15a, p.212].

[129] The oral erogenous zone consists of the mouth the oral mucous membrane.

[130] The anal erogenous zone consists of the anus and the mucous membrane of the rectum.

[131] The genital erogenous zone consists of the primary sexual organs.

[132] In this case the erogeneity – for both genders – relates to the phallus (in women, it also transitions to the clitoris).

[133] Discharge of libido means that the drive tension is reduced by a certain value upon stimulation of erogenous zones (satisfaction), which represents pleasure.

Input

- Numerical value representing the increase in libido
- List of neurosymbols, each of which consists of sensor type and sensor value and represents a particular erogenous zone.

Output

List of sexual drive representatives (drive source, quota of affect[134]):

- Sexual drive representative (oral, quota of affect)
- Sexual drive representative (anal, quota of affect)
- Sexual drive representative (genital, quota of affect)
- Sexual drive representative (phallic, quota of affect)

Interface to Personality Parameters

- Oral partial drive share of undischarged libido
- Anal partial drive share of undischarged libido
- Genital partial drive share of undischarged libido
- Phallic partial drive share of undischarged libido

Interface to Cyclic Storage

- Quotas of affect of the sexual drive representatives

7.2 Self-Preservation Drive Track

Like the sexual drive track described in Section 7.1, the self-preservation drive track includes elements in all three layers and consists of 3 functions (Fig. 7.3). Since the functions of Layer 1 and Layer 2 are only taken into consideration at a very abstracted level, i.e. as dummies, their description can be kept to a bare minimum and is thus restricted here to a reference to Sections 7.1.1 and 7.1.2.

[134] The generation of the remaining elements required for a complete drive representative occurs in other modules: drive component in F48, aim of drive and drive object in F57.

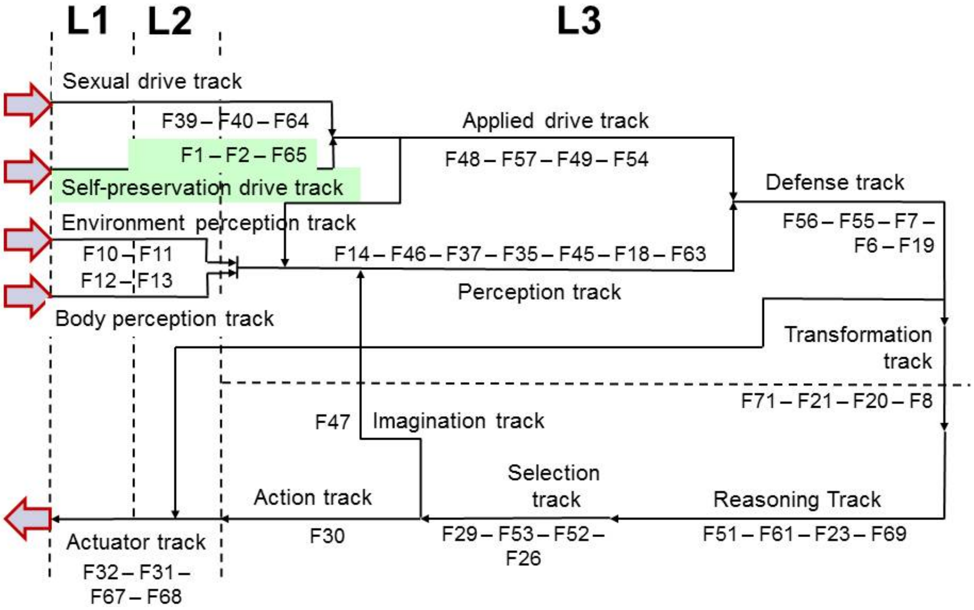

Fig. 7.3: Self-preservation drive track

7.2.1 Function F1: Sensors Metabolism

Function F1 is part of the self-preservation drive track as per Fig. 7.3 and possesses the following interfaces:

- Input I0.2
- Output I1.2
- Personality parameter DP2

General Functional Description

Bodily states like homeostasis, stomach fill level, blood parameters like blood sugar level, hormone levels (e.g. insulin) etc. are registered. These values are not made directly available to the secondary process. In the SiMA model, the table provided under "output" is defined as an output value vector.

Input

I0.2: Physical sensor input values which are reflected in the output.

Output

I1.2: Electrical output values.

Interface to Personality Parameter DP2

Personality-related bodily parameters like stomach size.

7.2.2 Function F2: Neurosymbolization of Needs

Function F2 is part of the self-preservation drive track. It is located in Layer 2 and possesses the following interfaces:

- Input I1.2
- Output I2.2

General Functional Description

The electrical data coming in through interface I1.2 are condensed into symbols.

Input

I1.2: Electrical signals leading to corresponding symbols at output I2.2.

Output

I2.2: Weighted symbols of the corresponding sensor inputs. In SiMA, these are:

- Stomach contents
- Energy consumption
- Internal pressure
- Body state
- Stamina
- Stomach tension
- Adrenaline
- Blood sugar level
- Energy
- Body temperature

7.2.3 Function F65: Generation of Quotas of Affect for Self-Preservation Drives

Function F65 is part of the self-preservation drive track (Fig. 7.3). It is located in Layer 3 and possesses the following interfaces:

- Input I2.2
- Output I3.4
- Output psychic intensity DT1
- Interface to data in cyclic storage

General Functional Description

In F65, drive representatives are generated from the registered bodily states (the drives). Drive representatives are mental representations in Layer 3 of bodily needs in Layer 1. Self-preservation drives are necessary in order to maintain an individual's life; this occurs by striving for homeostatic balance. A drive representative is represented via 3 contents and the quota of affect:

- Drive source (inner-somatic source, e.g. an organ),

- Aim of drive (generally satisfaction, specifically the action through which satisfaction can be achieved),
- Drive object (on or through which the drive goal can be achieved) and
- Quota of affect (a quantification of the drive tension).

Self-preservation drives are separated into libidinous and aggressive components.

The following list shows the sources of bodily needs for drive representatives:

- Blood sugar level
- Fill level of the rectum
- Muscular fatigue
- …

Input

List of homeostatic neurosymbols from the sensors of the abovementioned drive sources.

Output

List of self-preservation drives (drive source, quota of affect)[135]:

- Self-preservation drive representative (stomach, quota of affect)
- Self-preservation drive representative (stamina, quota of affect)
- Self-preservation drive representative (rectum, quota of affect)
- Self-preservation drive representative (fluid balance, quota of affect)

Interface to Cyclic Storage

Quotas of affect of the self-preservation drive representatives

7.3 Applied Drive Track

The drive representatives from the self-preservation and sexual drive tracks are formed in the applied drive track using existing memory traces so that psychic intensity is represented in the aim of drive, drive object and quota of affect. Furthermore, the drive representatives are re-valuated via primally repressed and repressed contents before the personality-related (via the neutralization rate) subtraction of quotas of affect.

[135] The generation of the remaining elements required for a complete drive representative occurs in other modules: drive component in F48, aim of drive and drive object in F57.

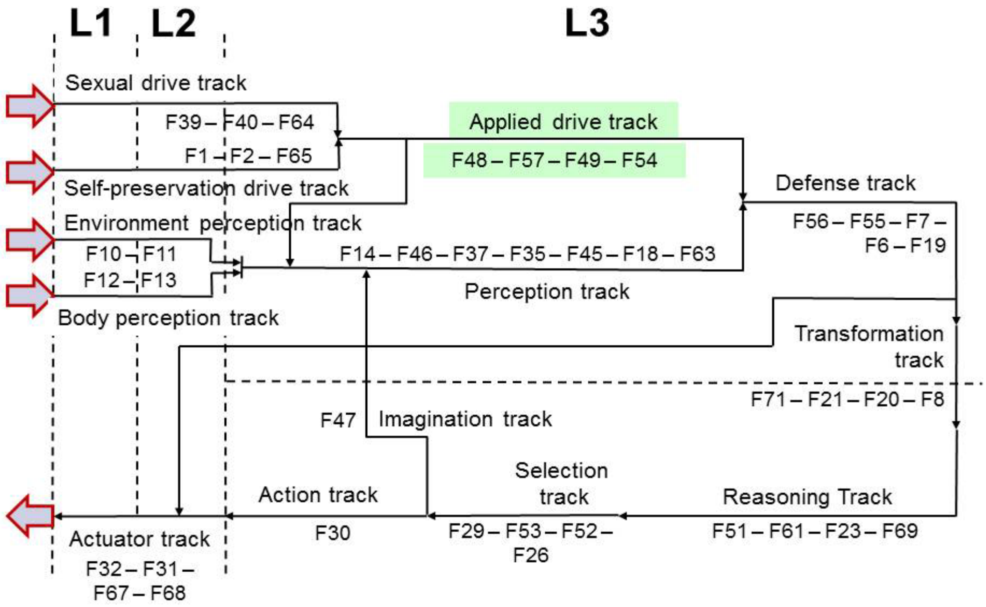

Fig. 7.4: Applied drive track

7.3.1 Function F48: Generation of Drive Components

Function F48 is part of the applied drive track (Fig. 7.4) and possesses the following interfaces:

- Input I3.3
- Input I3.4
- Output I4.1
- Output psychic intensity DT1
- Output emotion (pleasure)
- Interface to data in the cyclic storage

General Functional Description

The representatives of the sexual drives and the self-preservation drives are separated into aggressive and libidinous drive representatives according to their drive components and compiled into a joint list. The amount of reduction of drive tension is subsequently calculated for all drives. This value is interpreted as pleasure.

Input

- List of self-preservation drives (drive source; quota of affect)[136]; see output of F65 (Generation of Quotas of Affect for Self-Preservation Drives):
    - Self-preservation drive representative (stomach, quota of affect)

[136] The generation of the remaining elements required for a complete drive representative occurs in other modules: quotas of affect in F64 and F65, aim of drive and drive object in F57.

  - Self-preservation drive representative (stamina, quota of affect)
  - Self-preservation drive representative (rectum, quota of affect)
  - Self-preservation drive representative (fluid balance, quota of affect)
- List of sexual drives (drive source, quota of affect); see output of F64 (Generation of Quotas of Affect for Sexual Drives):
  - Sexual drive representative (oral, quota of affect)
  - Sexual drive representative (anal, quota of affect)
  - Sexual drive representative (genital, quota of affect)
  - Sexual drive representative (phallic, quota of affect)

Output

List of sexual and self-preservation drives (drive source; drive component; quota of affect)[137]:

- Self-preservation drive representative (stomach; aggressive, quota of affect)
- Self-preservation drive representative (stomach; libidinous, quota of affect)
- Self-preservation drive representative (stamina; aggressive, quota of affect)
- Self-preservation drive representative (stamina; libidinous, quota of affect)
- Self-preservation drive representative (rectum; aggressive, quota of affect)
- Self-preservation drive representative (rectum; libidinous, quota of affect)
- Self-preservation drive representative (fluid balance, aggressive; quota of affect)
- Self-preservation drive representative (fluid balance, libidinous; quota of affect)
- Sexual drive representative (oral; aggressive, quota of affect)
- Sexual drive representative (oral; libidinous, quota of affect)
- Sexual drive representative (anal; aggressive, quota of affect)
- Sexual drive representative (anal; libidinous, quota of affect)
- Sexual drive representative (genital; aggressive, quota of affect)
- Sexual drive representative (genital; libidinous, quota of affect)
- Sexual drive representative (phallic; aggressive, quota of affect)
- Sexual drive representative (phallic; libidinous, quota of affect)

Interface to Personality Parameters

- Relations of aggressive to libidinous components of the sexual drive representatives.
- Relations of aggressive to libidinous components of the self-preservation drive representatives.

Interface to Cyclic Storage

Pleasure is generated from the registered drive discharge of quotas of affect, and its value is stored in the cyclic storage.

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[137] The generation of the remaining elements required for a complete drive representative occurs in other modules: quotas of affect in F64 and F65, aim of drive and drive object in F57.

7.3.2 Function F57: Generation of Drive Representatives

Function F57 is part of the applied drive track (Fig. 7.4) and possesses the following interfaces:

- Input I4.1
- Output I5.1

General Functional Description

Drive objects and aims of drive as possibilities for satisfaction of the drive components generated in F48 (Generation of Drive Components) are remembered. Drive representatives are created through association of the drive components with remembered drive objects and aims of drive. This process represents hallucinatory wish fulfilment, i.e. the activation of a primitive functionality of the psyche subject to the pleasure principle: the wish to repeat a previously experienced satisfaction can be fulfilled in the primary process through hallucination of memory traces.

After the generation of drive components in F48 (Generation of Drive Components), the components seek possible drive objects; this occurs by searching the memory traces. The drive component activates those drive objects which have successfully satisfied it in the past causing pleasure gain. This leads to an association with all possible drive objects from the memory. Furthermore, the action (aim of drive) which led to satisfaction of the drive via the drive object is also remembered. The result of this process is the connection of the drive component with the remembered drive objects and actions. The relevance of the remembered drive objects is taken into consideration for the drive representative, since generally the different remembered drive objects will have satisfied the drive component with different amounts of pleasure gain.

Cathexis of potential drive objects occurs during the course of hallucinatory wish fulfilment. This means that the quotas of affect gained from the current drive tensions are assigned to potential drive objects; from the perspective of computer engineering, the drive object is valuated. This process also takes into consideration that an individual drive object may be remembered for more than one drive.

Input

Drive components (currently 16: aggressive and libidinous drive representatives of the four self-preservation drives (originating from the stomach, stamina, rectum, and fluid balance), and aggressive and libidinous drive representatives of the oral, anal, genital and phallic sexual drives).

Output

Drive representatives (currently 16: aggressive and libidinous drive representatives of the four self-preservation drives (originating from the stomach, stamina, rectum, and fluid balance), and aggressive and libidinous drive representatives of the oral, anal, genital and phallic sexual drives).

7.3.3 Function F49: Primal Repression for Drive Wishes

Function F49 is part of the applied drive track (Fig. 7.4) and possesses the following interfaces:

- Input I5.1
- Output I5.2
- Personality parameter DP7

General Functional Description

In function F49, current drive wishes are associated with drive wishes from the storage of primally repressed contents. In the case of correspondence, contents are appropriately repressed and/or their quotas of affect altered depending on the degree of correspondence.

The result of function F49 is the attachment of marked primally repressed contents to the remembered drive objects, so long as they are associable. The association of primally repressed contents with drive objects leads to a change in the quotas of affect of the corresponding drive representatives.

Primally repressed contents are personality-specific.

Input

I5.1: Drive representatives with remembered thing presentations (current drive wishes)

Output

I5.2: Altered drive wishes. The drive wishes are changed through association with primally repressed contents.

Personality Parameter DP7

Repressed contents

7.3.4 Function F54: Emersion of Blocked Drive Content

Function F54 is part of the applied drive track (Fig. 7.4) and possesses the following interfaces:

- Input I5.2
- Output I5.3
- Input of repressed contents DT2

General Functional Description

In function F54, repressed drive contents and quotas of affect can be connected to currently incoming drive representatives if an appropriate association was found. By this mechanism, repressed drive representatives constantly attempt to bypass the defense mechanisms via other contexts.

Input

I5.2: Current drive representatives.

Interface to Cyclic Storage

DT2: Repressed contents.

Output

I5.3: Current drive representatives with attached repressed drive representatives consisting of the following elements:

- Drive source
- List of aims of drive
- List of drive objects
- Quota of affect

7.4 Environment Perception Track

The environment perception track includes elements in Layer 1 and Layer 2 and consists of two functions (Fig. 7.5). Once again, since the functions of Layer 1 and Layer 2 are only taken into consideration at a very abstracted level, i.e. as dummies, their description can be kept to a bare minimum and is thus restricted here to a reference to Sections 7.1.1 and 7.1.2.

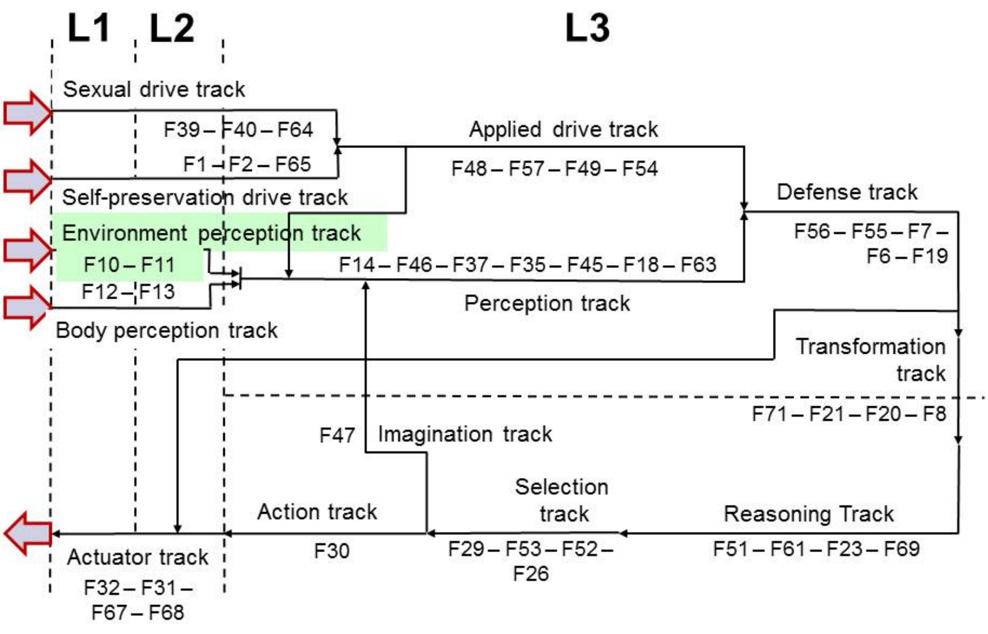

Fig. 7.5: Environment perception track

7.4.1 Function F10: Sensors Environment

Function F10 is part of the environment perception track (Fig. 7.5) and possesses the following interfaces:

- Input I0.3
- Output I1.3
- Personality parameter DP 3

General Functional Description

The data from the five senses (sight, smell, hearing, touch, and taste) are processed into images and motions.

Input

I0.3: Physical sensor input parameters from the 5 human senses.
I1.3: Electrical output parameters derived from I0.3.

Interface to Personality Parameter DP3

Personality-related bodily attributes like state of hearing.

7.4.2 Function F11: Neurosymbolization Environment

Function F11 is part of the environment perception track (Fig. 7.5). It is located in Layer 2 and possesses the following interfaces:

- Input I1.3
- Output I2.3

General Functional Description

The electrical data coming in via interface I1.3 are condensed into symbols.

Input

I1.3: Electrical signals leading to corresponding images and motions at output I2.3.

Output

I2.3: Weighted images and motions from the various sensor inputs

7.5 Body Perception Track

Like the environment perception track in Section 7.4, the body perception track includes elements in Layer 1 and Layer 2 and consists of two functions (Fig. 7.6). Once again, since the functions of Layer 1 and Layer 2 are only taken into consideration at a very abstracted level, i.e. as dummies, their description can be kept to a bare minimum and is thus restricted here to a reference to Sections 7.1.1 and 7.1.2.

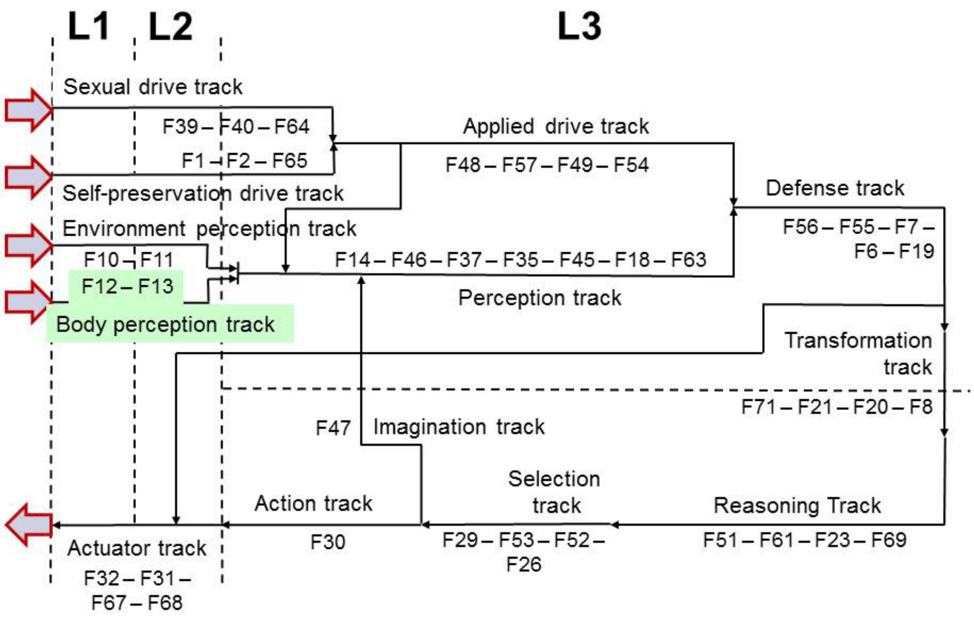

Fig. 7.6: Body perception track

7.5.1 Function F12: Sensors Body

Function F12 is part of the body perception track (Fig. 7.6) and possesses the following interfaces:

- Input I0.4
- Output I1.4
- Personality parameter DP 4

General Functional Description

The data from the body sensors (stance of muscles from proprioception, pain nerves, etc.) are processed into images and motions.

Input

I0.4: Physical sensor input parameters of bodily states.

I1.3: Electrical output data derived from I0.4.

Interface to Personality Parameter DP4

DP4: Personality-related bodily attributes like sensitivity to pain or pressure; none are as yet implemented in the current SiMA model.

7.5.2 Function F13: Neurosymbolization Body

Function F13 is part of the body perception track (Fig. 7.6). It is located in Layer 2 and possesses the following interfaces:

- Input I1.4
- Output I2.4

General Functional Description

The electrical data coming in through interface I1.4 are condensed into symbols.

Input

I1.4: Electrical signals leading to corresponding images and motions at output I2.4.

Output

I2.4: Weighted images and motions from the various sensor inputs.

7.6 Perception Track

In the perception track, data from perception are processed by way of being linked with subjective information from the psyche like memory traces or repressed and primally repressed contents. This results in variegated cathexes and interlinking of perception data via quotas of affect and associated contents. Valuation also occurs via emotion through a compilation of various quotas of affect in the psychic apparatus and their association.

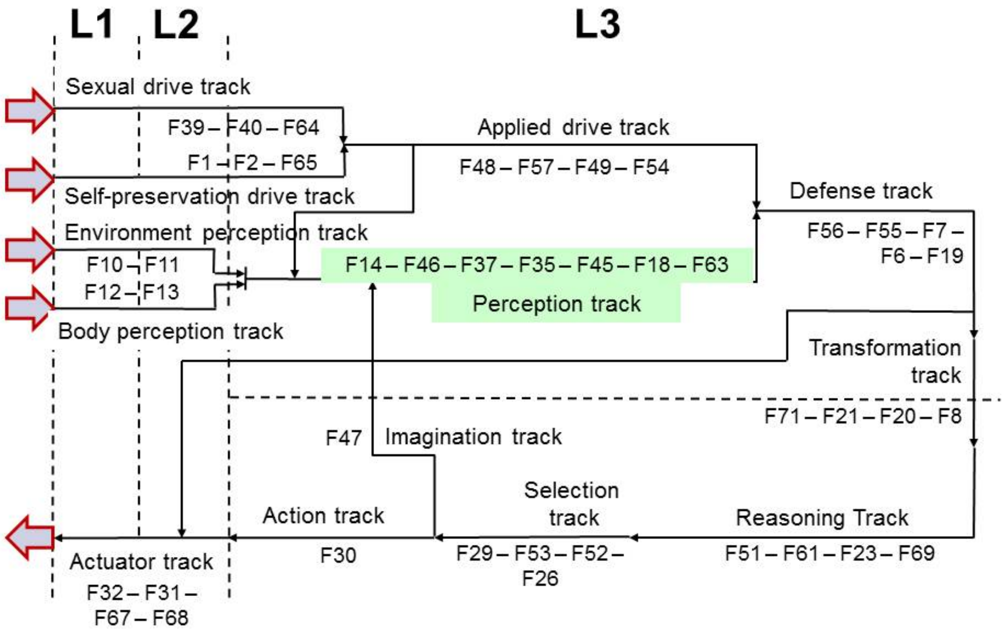

Fig. 7.7: Perception track

7.6.1 Function F14: External Perception

Function F14 is part of the perception track (Fig. 7.7) and possesses the following interfaces:

- Input I2.3
- Input I2.4
- Input I5.1
- Output I2.6

General Functional Description

Function F14 is the first function of the perception track in the third functional layer. Transformation of the multimodal neurosymbols (images and motions) into thing presentations occurs here. Neurosymbols are psychically defined as perception content regarding the environment and thus represent thing presentations.

In the primary process, perception is modeled as a means of drive fulfilment for the agent. In this context, F14 associates appropriate valuated memories with objects of the environment, which allows those objects to be recognized. Recognition of objects is based on memories and expectations of the agent which are generated by drive representatives and emotions. Hence memories associated with perception objects are activated by diverse sources (neurosymbols, drive representatives, emotions).

Input

Specific data:

- Neurosymbols of the environment
- Neurosymbols of the body

Output

Images and motions.

7.6.2 Function F46: Memory Traces for Perception

Function F46 is part of the perception track (Fig. 7.7) and possesses the following interfaces:

- Input I2.6
- Input I5.19
- Output I5.6
- Interface to long-term memory
- Interface to short-term memory

General Functional Description

All the objects loaded into F14 (External perception) and identified are merged into a *perceived image*/*perceived motion*. The perceived image/perceived motion consists of all perceived objects appearing within in a certain time period. After this, memories (template images/template motions) are activated. The selection of activated images/motions depends on the following elements: the perceived image/perceived motion, images/motions activated in previous cycles, objects fantasized in previous cycles, and the current drive state. For the activation of memories, the perceived image/perceived motion is additionally supplemented with contents from the localization storage (part of the short-term memory) in order to take objects outside of the agent's immediate field of vision (e.g. behind the agent) into consideration.

Input

I2.6:

- Lists of images and motions of physical objects
- Lists of drive representatives from F14 via I5.1

I5.19: Images and motions from the fantasy (imagination track) transformed for the primary process.

Output

I5.6: An image/motion mesh consisting of a perception (perceived image/perceived motion) and activated memories (template images/template motions).

Interface to Short-Term Memory

Access to images and motions relating to the environment

7.6.3 Function F37: Primal Repression for Perception

Function F37 is part of the perception track (Fig. 7.7) and possesses the following interfaces:

- Input I5.6
- Output I5.7
- Personality parameter DP7

General Functional Description

Function F37 connects contents from the current perception (images and motions) with primally repressed contents that it obtains from personality parameters. If an associative connection occurs, the result is a change in the subjective valuation of the perception (images/motions). Quotas of affect are reduced and perception contents are transferred to repression.

Input

I5.6: Current perception (perceived images/perceived motions); activated memories (template images/template motions)

Output

I5.7: Current perception (perceived images/perceived motions); activated memories (template images/template motions)

In the output of function F37, the current perception consists of the subjectively adapted images/motions.

7.6.4 Function F35: Emersion of Blocked Content

Function F35 is part of the perception track (Fig. 7.7) and possesses the following interfaces:

- Input I5.7
- Output I5.8
- Interface to cyclic storage (DT2: repressed contents)

General Functional Description

The images and motions incoming from F37 (Primal repression for perception) are compared with the repressed contents; depending on the degree of correspondence, the repressed contents are attached to the images and motions.

Input

I5.7: Memories activated through perception (images and motions).

Output

I5.8: Activated memories (images and motions), attached contents.

7.6.5 Function F45: Discharge of Psychic Intensity

Function F45 is part of the perception track (Fig. 7.7) and possesses the following interfaces:

- Input I5.8
- Output I5.9
- Output psychic intensity DT1

General Functional Description

The perception of executed aims of drive causes the discharge of quotas of affect related to the respective drives. This applies to actions by the agent which offer no direct feedback via the body. For example: eating a Schnitzel changes the state of the stomach, causing a drive satisfaction to be recognized. This is not, however the case for the act of sharing; in this case, only the knowledge of the action – gained e.g. through perception – can cause the satisfaction of a drive to be recognized. This is especially the case when satisfaction of a drive requires a sequence of actions.

Input

I5.8: Images and motions.

Output

I5.9: Images and motions.

7.6.6 Function F18: Composition of Quotas of Affect for Perception

Function F18 is part of the perception track (Fig. 7.7). It is located in Layer 3 and possesses the following interfaces:

- Input I5.9
- Output I5.10

General Functional Description

In function F18, the impacts of the functions F37 (Primal repression for perception) and F35 (Emersion of blocked content) on the quotas of affect of the memory traces activated in F46 (Memory traces for perception) are combined and the quotas of affect appropriately corrected. Both of the functions F35 and F37 change thing presentations by creating additional associative connections to drive representatives which are often equivalent to already existing connections. In F18, all thing presentations (from perception and from activated memories) are searched for such multiple, equivalent connections between thing presentation and drive representative, and any equivalent connections found are combined. In this context, two connections between thing presentation and drive representative are considered equivalent if they are connected to the same thing presentation and the drive component, partial drive, drive source and aim of drive of the drive representative match.

The various possible reasons for the creation of such additional, sometimes equivalent connections are discussed in detail in the descriptions of the functions F35 (Primal repression for perception, Section 7.6.3) and F37 (Emersion of blocked content, Section 7.6.4).

Input

I5.9: Thing presentation mesh consisting of current perception and perception-dependently activated memories, with adaptations (subjectivation) from functions F35 and F37 not yet represented in the quotas of affect.

Output

I5.10: Thing presentation mesh consisting of current perception and perception-dependently activated memories in which the quotas of affect have been corrected according to the adaptations (subjectivation) made in functions F35 and F37.

7.6.7 Function F63: Composition of Emotions

Function F63 is part of the perception track (Fig. 7.7) and possesses the following interfaces:

- Input I5.3
- Input I5.10
- Output I5.21
- Input pleasure DT4

General Functional Description

Emotions are an additional valuation level. They include:

1. Quotas of affect from the drive representatives,
2. the remembered emotions activated by perception and fantasy (with memories of associated basic and extended emotions), and
3. the agent's current state of pleasure.

Hence emotions represent drive representatives as well as valuations activated by perception (environment and body perception) and fantasy. The representation of the somatic state occurs through drives and body perception (internal perception, pain and external perception). It must however be emphasized that – in the sense of the 3-layered model – the corresponding psychic representatives (drive representatives and body representatives) are used for the composition of emotions and not the actual bodily signals. The psychic aspect of the psycho-somatic[138] state is intensified through the memories activated by environment perception and fantasy (in particular by the emotional body states associated with these memories).

The composition of emotions is dependent on the four emotional scalars which form the emotion vector: pleasure, unpleasure, the aggressive portion of the quotas of affect[139] and the libidinous portion of the quotas of affect.

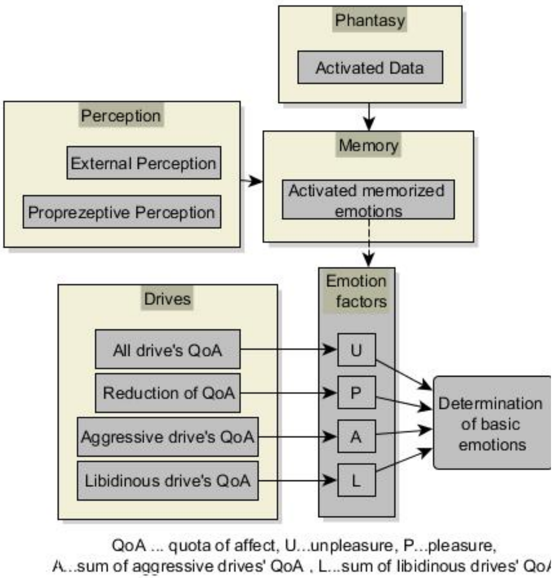

Fig. 7.8: Influences on the composition of emotions [Sch 13]

Only *basic emotions* are composed for the first time in F63 (Fig. 7.8). These basic emotions are not learned, meaning they are organic to the brain and humans possess them as genetic predisposition.

[138] In this context, the term *psycho-somatic* indicates the effects of physiological processes on the psyche and vice versa.

[139] More precisely: the sum of the quotas of affect of the aggressive drive representatives.

The number and names of the basic emotions (e.g. according to Panksepp: seeking, anxiety, anger and panic) differ between various models of emotion [Sol 04, 128ff.; Pan 98, 51ff.]). In the SiMA model, they are as follows: happiness, anger, anxiety, sadness, elation and satiation. It must be emphasized that this specification is purely one for the purpose of modeling (similar to how an agent would ascribe the emotions to another agent due to his perceived external state).[140] The agent is not aware which emotions he currently has and can therefore not name them. Only after their transformation as feeling can he reflect on them and identify them as anxiety, anger, etc.

Different basic emotions are represented by the emotion vector depending on the constellation of its emotional scalars. The psycho-somatic state of the agent is represented by a subset of the following basic emotions:

- A dominance of pleasure is represented by happiness.
- A dominance of unpleasure is represented by fear.
- The dominance of unpleasure and a high libidinous component results in sadness.
- The dominance of unpleasure and a high aggressive component results in anger.
- The dominance of pleasure and a high libidinous component results in satiation.
- The dominance of pleasure and a high aggressive component results in elation.

Input

Specific data:

- I5.3: Drive representatives (currently 16: aggressive and libidinous drive representatives of each of four self-preservation drives (originating from the stomach, fluid balance, stamina and rectum), aggressive and libidinous drive representatives of oral, genital, anal and phallic sexual drives).
- I5.10: Images from perception.

Output

I5.21: List of basic emotions; the following are possible: happiness, anxiety, sadness, anger, satiation, elation.

7.7 Defense Track

Sub-functions of the super-ego and the ego are integrated in the defense track. The super-ego function as a whole is one of the three instances defined in the second topographical model; it contains prohibitions, imperatives and gratifications and demands their observation. The synthetic-integrative ego functions[141] decide whether and in what way drive wishes or perceptions are not allowed for continued processing towards becoming conscious. Thus their principal task is to resolve the conflicts constantly arising in the primary process using the procedural patterns defined in the defense mechanisms.

[140] The designation of a thing presentation receives its word presentation only through association with a word/term.

[141] See Section 5.5 (*Task of the Functions at Level 3 (of Layer 3))*

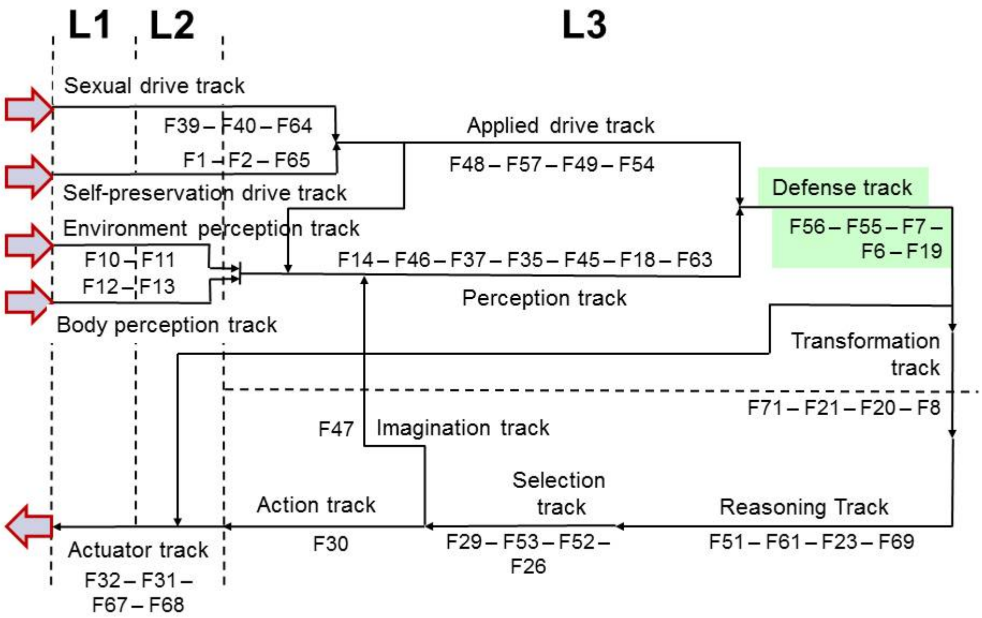

Fig. 7.9: Defense track

7.7.1 Function F56: Desexualization/Neutralization

Function F56 is part of the defense track (Fig. 7.9) and possesses the following interfaces:

- Input I5.3
- Output I5.4
- Input and Output of neutralized psychic intensity DT3
- Output pleasure DT4
- Personality parameter: degree of psychic neutralization

General Functional Description

After the drive representatives with their corresponding quotas of affect have been created, a part of the quotas of affect of all drives is transformed into *neutralized psychic intensity* in F56 according to the personality parameter degree of psychic neutralization. The neutralized intensity thus derived from the drive tension is made available to other modules. It is important to note in this context that – conceptually speaking – neutralized psychic intensity is simply a form of psychic intensity and therefore represents a form of valuation which allows a greater spectrum of possible uses. It is available to ego functions and their tasks and also controls their functionality. By contrast, the original psychic intensity conducts cathexes only via the functions of the id.

The amount of psychic intensity transformed into neutralized psychic intensity is determined by two personality parameters representing the respective transformation shares of the quotas of affect of the self-preservation and sexual drives. For example, 80% of the quotas of affect of the sexual drives and 50% of the quotas of affect of the self-preservation drives are available to the agent Adam. This personality-specific ratio can be viewed as a base value that reflects the personality of the respective agent. However, various current internal states can subsequently alter these ratios for the apportionment of drive intensity. For instance, the agent's activity (e.g. intensive planning) can affect the share of drive intensity that is transformed.

In the simulation, a cyclic storage module (DT3) is available for storing the value of neutralized psychic intensity. This also serves to distribute the neutralized psychic intensity to the various modules that use it. In F56, the apportionment of neutralized psychic intensity for the various modules is determined and the values transferred to the cyclic storage DT3. Each module possesses a reserved area in the cyclic storage. The stored neutralized psychic intensity is not lost over time, but is distributed anew after each cycle of the model.

Input

I5.3: Drive representatives

Output

I5.4: Drive representatives, neutralized psychic intensity

7.7.2 Function F55: Super-Ego Proactive

Function F55 is part of the defense track (Fig. 7.9) and possesses the following interfaces:

- Input I5.4
- Input I5.21
- Output I5.5
- Output I5.12
- Output I5.14
- Input psychic intensity DT1
- Personality parameter DP10
- Interface to data in the cyclic storage

General Functional Description

Function F55 is part of the super-ego functions and operates with unconscious data. Within it, drive wishes, emotions and perceptions come into conflict with existing (proactive) super-ego rules. The difference to function F7 (Super-ego reactive) is that F55 does not require any incoming drive wishes or emotions to become active. Function F55 becomes active depending on a personality-specific threshold value for neutralized psychic intensity and makes demands like "Do a good deed every day!"

In the case of conflicts, e.g. between id and super-ego, the defense is subsequently activated via F6 (Defense mechanisms for drive wishes) or F19 (Defense mechanisms for perception).

Input

Input of F55 are drive wishes and emotions:

I5.4: Current drive representatives

I5.21: Current emotions

Output

The output of function F55 are drive wishes and emotions altered according to the proactive super-ego rules (identical for I5.5, I5.12 and I5.14):

- Altered drive representatives
- Altered emotions

7.7.3 Function F7: Super-Ego Reactive

Function F7 is part of the defense track (Fig. 7.9) and possesses the following interfaces:

- Input I5.10
- Input I5.12
- Output I5.11
- Output I5.13
- Input psychic intensity DT1
- Personality parameter DP11
- Interface to data in the cyclic storage

General Functional Description

Function F7 is part of the super-ego functions and operates with unconscious data. In the function F7 drive wishes, emotions and perceptions conflict with existing super-ego rules.

The amount of conflict strength which is caused by a drive wish, emotion, or perception in regard to the super-ego rules is calculated in F7. This conflict strength is transmitted to the defense together with the drive wishes, emotions, and perceptions causing the conflict.

All drive wishes, emotions and perceptions are transmitted to the defense unaltered, however.

Input

Input of F7 are drive wishes , emotions, and perceptions.

5.10: Current perceptions

5.12: Current drive representatives and current emotions

Output

The output of function F7 are lists of drive wishes, emotions and perceptions which are in conflict with super-ego rules. The corresponding conflict strength, i.e. the intensity of the conflict, is listed with each of these drive wishes, emotions and perceptions.

In addition, all incoming drive wishes, emotions and perceptions are passed on to the defense mechanisms unaltered.

I5.11:

- Perceptions (used in F7 to detect conflicts with the super-ego, but are not modified)
- Emotions (used in F7 to detect conflicts with the super-ego, but are not modified)
- List of conflicts (including the corresponding conflict strength) between perceptions and super-ego rules
- List of conflicts (including the corresponding conflict strength) between emotions (e.g. anger) and super-ego rules

I5.13:

- Drive representatives (used in F7 to detect conflicts with the super-ego, but are not modified)
- List of conflicts (including the corresponding conflict strength) between drive representatives and super-ego rules

7.7.4 Function F6: Defense Mechanisms for Drive Wishes

Function F6 is part of the defense track (Fig. 7.9) and possesses the following interfaces:

- Input I5.5
- Input I5.13
- Output I5.17
- Output I5.18
- Output repressed content DT3
- Personality parameter DP9

General Functional Description

Function F6 represents the defense mechanisms for drive wishes and decides which of the available input data are allowed to become preconscious or conscious, and in what way. It is part of the ego functions and operates with unconscious data. Defense mechanisms are used by the ego to resolve conflicts, and function F6 decides which defense mechanisms are triggered.

The following types of defense are possible:

- Drive wishes can pass through the defense unaltered.
- Drive wishes are partially or completely changed before being passed on.
- Drive wishes are completely or partially suppressed (defense mechanism repression for drive wishes).

Input

I5.5: List of conflicting drive representatives
I5.13: List of all drive representatives

Output

I5.17: Detached quotas of affect which have been dissociated from drive representatives in the course of the defense process
I5.18: Drive representatives allowed to become preconscious or conscious.

7.7.5 Function F19: Defense Mechanisms for Perception

Function F19 is part of the defense track (Fig. 7.9) and possesses the following interfaces:

- Input I5.11
- Input I5.14
- Output I5.15
- Output I5.16
- Output repressed content DT2
- Personality parameter DP13

General Functional Description

Function F19 represents the defense mechanisms for perception and decides which perceptions are allowed to become preconscious or conscious. It is part of the ego functions and operates with unconscious data. Aftera detected conflict, the function F19 decides whether defense mechanisms are triggered and which defense mechanisms are triggered. For example, in the case of projection, perceptions of the own self (self-representatives) are ascribed to another person (object representatives).

The following types of defense are possible:

- Perceptions are allowed to pass through the defense unaltered and unhindered.
- Perceptions are partially or completely changed before being passed on.
- Perceptions are completely or partially suppressed (defense mechanism denial for perception).

Input

- I5.11: Perceptions
- I5.11: Emotions
- I5.14: List of conflicting perceptions and corresponding conflict strength
- I5.14: List of conflicting emotions and corresponding conflict strength

Output

The outputs of function F19 are perceptions and emotions allowed to become preconscious or conscious as well as detached quotas of affect dissociated in the course of the defense process. Perceptions and emotions allowed to become preconscious or conscious are changed by the defense mechanisms in order to be no longer in conflict with super-ego rules.

I5.15:

- Perceptions changed by the defense mechanisms
- Emotions and quotas of affect changed by the defense mechanisms

I5.16: Detached quotas of affect

7.8 Transformation Track

In the transformation track, data are transformed to the secondary process. Word presentations are attached to the thing presentations to structure their contents in terms of causality and time.

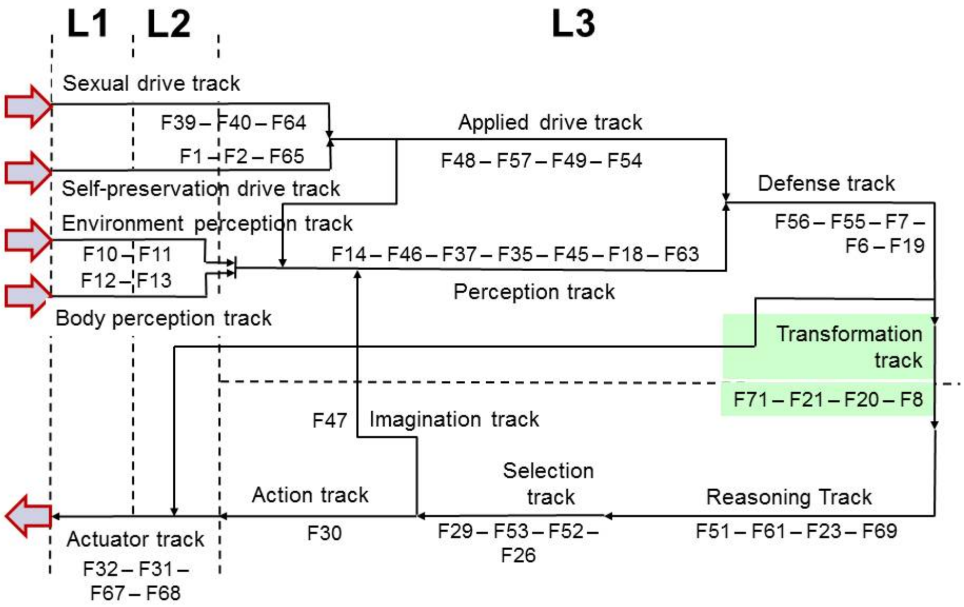

Fig. 7.10: Transformation track

7.8.1 Function F71: Composition of Extended Emotion

Function F71 is part of the transformation track (Fig. 7.10) and possesses the following interfaces:

- Input I5.16
- Input I5.17
- Output I5.20
- Output I5.21

General Functional Description

In function F71, defense mechanisms conduct accentuation of the basic emotions or associate an additional attribute[142]. The concrete processing of the basic emotions differs between the specific extended emotions and depends on the situation, the super-ego rules and the basic emotions.

[142] For example, the additional attribute for guilt is a conflict between the ego and the super-ego; for shame it is a conflict between the ego (the self-representative) and the ego-ideal.

Examples of extended emotions are shame, pity, envy or guilt.

Input

- Images
- Drive representatives

Output

Extended emotions

7.8.2 Function F21: Transformation to Secondary Process (Perception)

Function F21 is part of the transformation track (Fig. 7.10) and possesses the following interfaces:

- Input I5.15
- Output I6.1
- Input neutralized psychic intensity DT3
- Interface to long-term memory
- Personality parameter

General Functional Description

Function F21 conducts the transformation of perception content from the primary to the secondary process. The data structures of the primary process (thing presentation meshes with valuated contents) are expanded by the data structures of the secondary process (word presentation meshes[143] with valuated contents). This allows the agent to classify and logically process the images and motions represented by the thing presentation meshes. The input of F21 consists of a thing presentation mesh of images and motions allowed by the defense (F19), which in turn is composed of contents from perception and activated memories.

First the perceived image is extracted from the thing presentation mesh. For every image occurring as an element of this perceived image, long-term memory is searched for an associable word presentation which is then added to the output to be generated. The result is a new perceived image consisting of a primary and a secondary process component. The same applies to motions.

External associations with word presentation meshes associated with other images are also activated. Such associations represent logical connections between the images, for example the temporal sequence of the individual images of an act, represented by the association “hasNext” between an image and its temporal successor.

[143] A word presentation is a complex of associated presentations which represent a word in the natural language. This includes the sound pattern, reading pattern, writing pattern and movement pattern, with the sound pattern being predominant in regard to common language practice.

F21 uses a limited amount of neutralized psychic intensity in order to filter the perceived and activated remembered images. In order for the psyche to operate efficiently, not all contents from perception or all activated memories can be made available at once; instead only a selection relevant for the current situation is used. The forming of relations between elements from perception can be taken as an example: forming relations between four elements – each element with each other element – results in (4-1)! = 6 relations, which is a relatively manageable number. However, forming relations in the same fashion between 25 elements results in (25-1)! = 6^{23} relations, a number which the agent cannot handle. The more neutralized psychic intensity is available, the more perceived and remembered contents can be provided as output.

To achieve this selection, the list of memories is reduced to acts, i.e. the list of individual images is reduced to a single image for every act. The rest of the act remains reachable via the logical associations. The logical associations are now activated for all images, meaning also for those images that were not activated in the primary process. An example is a sequence consisting of a total of three images, with only two of those images having been activated in the primary process. The primary process component for the third image is missing. It is nevertheless attached to the memories, since precisely this image might be required for an important assessment. The entrainment of the incomplete image subsequently allows the missing image to be searched for and used in the decision-making process.

The associations between the thing presentation meshes of the images are independent of the associations of the word presentations connected to them. This results in several independent word presentation meshes being created in the secondary process from the original thing presentation mesh in the primary process – in particular, one word presentation mesh for every act. All activated word presentation meshes are passed on in the secondary process.

Functionality regarding short-term memory: each time the cycle starts in the secondary process, the time variable in the short-term memory must be incremented by 1. This means that the contents stored in the previous cycle are to be viewed as historic. By definition, this occurs in F21, the first function in the cycle to run within the secondary process.

Input

I5.15: Thing presentation mesh consisting of the perceived images and motions as well as the activated memories (template images), with the perceived images coming from the output of function F19; neutralized psychic intensity DT3

Output

- Word presentation mesh associated with the perceived image (with reduced number of elements)
- List of word presentation meshes of remembered, associated images of acts

7.8.3 Function F20: Composition of Feelings

Function F20 is part of the transformation track (Fig. 7.10) and possesses the following interfaces:

- Input I5.21
- Output I6.2
- Input neutralized psychic intensity DT3
- Interface to long-term memory
- Personality parameter DP20

General Functional Description

Function F20 receives a list of extended emotions which the agent is currently experiencing from F71. A word presentation mesh is attached to each of these emotions that is the language-based expression of the respective emotion as a feeling. The urgency with which the function requests neutralized psychic intensity is determined by personality parameters. The more psychic intensity is available, the more differentiated a feeling can be represented with word presentations.

Input

I5.21: List of emotions

Output

I6.2: List of feelings

7.8.4 Function F8: Transformation to Secondary Process (Drive Wishes)

Function F8 is part of the transformation track (Fig. 7.10) and possesses the following interfaces:

- Input I5.18
- Output I6.3
- Input neutralized psychic intensity DT3
- Interface to long-term memory
- Personality parameter

General Functional Description

Function F8 represents the transition to the secondary process for drive wishes. The data structures of the primary process are expanded by the data structures of the secondary process, the *goals*. The inputs for F8 are the drive wishes allowed by the defense (F6), stored as a list of drive representatives and the corresponding associations. For each drive representative, a corresponding goal is added to the output list.

The more psychic intensity is available, the more drive wishes can be designated as goals of the agent. The urgency with which the function requests neutralized psychic intensity is determined by personality parameters.

The output of goals is subsequently sorted by quota of affect.

Input

I5.18: List of drive representatives

Output

I6.3: List of goals represented through word presentation meshes

7.9 Reasoning Track

In the reasoning track, the need is chosen which promises the greatest pleasure gain under consideration of external social rules and an acceptable level of unpleasure.

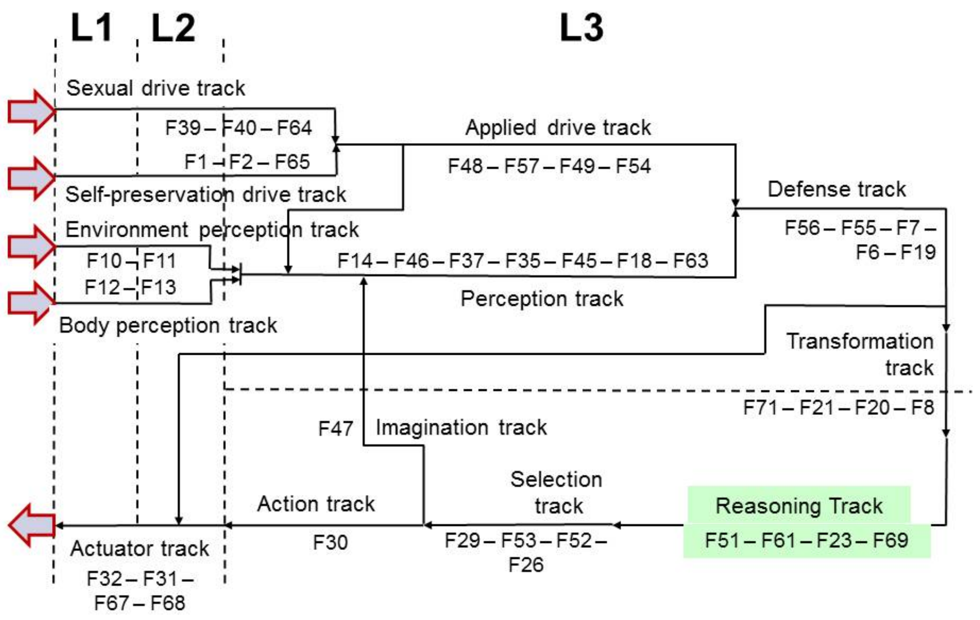

Fig. 7.11: Reasoning track

7.9.1 Function F69: Extraction of Possible Goals

Function F69 is part of the reasoning track (Fig. 7.11) and possesses the following interfaces:

- Input I6.2
- Input I6.3
- Output I6.14
- Interface to short-term memory

General Functional Description

Function F69 extracts all selectable goals available to the agent. These are: goals from perception, acts and aims of drive. All potential aims of drive are extracted from the perceived image/perceived motion. Any generalization of images/motions is treated in the same way as the perceived image/perceived motion, with possible goals being likewise extracted. If no selectable goal exists for a certain aim of drive, possible goals are defined in order to enable the agent to search for such goals.

Input

I6.2: Perceived images/perceived motions and acts

I6.3: List of drive representatives

Output

I6.14: Perceived images/perceived motions, acts, selectable goals

7.9.2 Function F23: Focus of Attention

Function F23 is part of the reasoning track (Fig. 7.11) and possesses the following interfaces:

- Input I6.14
- Output I6.13
- Interface to short-term memory

General Functional Description

Function F23 uses a limited amount of neutralized psychic intensity to focus perception. In order for the psyche to operate efficiently, not all contents from perception or all activated memories can be made available at once; instead only a selection relevant for the current situation is used. The functionality of this module is triggered by the action contained in the current planning goal of the agent. This action is stored in short-term memory and associated with the planning goal. Images and motions of this action are hypercathected via cathexis of attention using neutralized psychic intensity.

Input

I6.14: Perceived image/perceived motion, extracted selectable goals, planning goal

Output

I6.13: Filtered Perceived Image/perceived motion, extracted selectable goals

7.9.3 Function F61: Localization

Function F61 is part of the reasoning track (Fig. 7.11) and possesses the following interfaces:

- Input I6.13
- Output I6.12
- Interface to long-term memory
- Interface to short-term memory
- Interface to cyclic storage

General Functional Description

Function F61 is responsible for self-localization and map generation in a geographical sense. The short-term memory is used to generate a virtual 360° perceived image/perceived motion with identified landmarks out of the perceived images/perceived motions from several successive cycles. These landmarks are then compared to a cognitive map (from data stored in long-term memory) in order to determine the agent's current location. When the agent encounters new landmarks, they are added to the existing map (charted). This functionality by definition requires learning, which is incorporated for the first time within the SiMA framework in this function – with the exception of the initial version.[144]

Input

I6.13: Filtered perceived images/perceived motions, extracted selectable goals

Output

I6.12: Perceived image/perceived motion, extracted selectable goals

7.9.4 Function F51: Reality Check Wish Fulfilment

Function F51 is part of the reasoning track (Fig. 7.11) and possesses the following interfaces:

- Input I6.12
- Output I6.7
- Interface to short-term memory

General Functional description

Function F51 is responsible for checking whether the current wishes can be fulfilled in the external reality. This means checking whether the objects of the current goals exist in current perception, and whether their actions are executable in the external reality.

Input

I6.12: Perceived image, extracted selectable goals:

- Planning goal, selected goals of previous perceived moment[145]
- Environmental image: current environmental image

Output

[144] This example clearly illustrates that *learning* is function-specific, meaning that one cannot speak of generalized learning; each function must be assigned a specific learning functionality. As mentioned before, this train of thought can likewise be applied to the concept of *intelligence*.

[145] This topic is currently being addressed in the ongoing project SELF [SEL 13].

I6.13: Selectable goals, environmental image

7.10 Selection Track

Out of the different possible action plans developed in the thought process, the action plan promising the greatest pleasure gain in the given planning horizon on the basis of the various valuations is selected in the selection track.

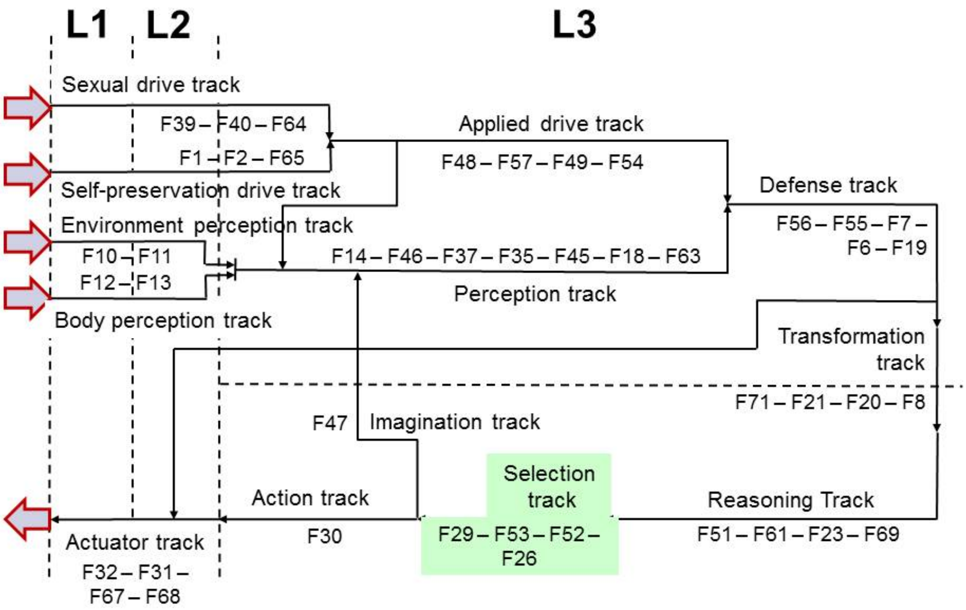

Fig. 7.12: Selection track

7.10.1 Function F26: Decision Making

Function F26 is part of the selection track (Fig. 7.12) and possesses the following interfaces:

- Input I6.1
- Input I6.3
- Input I6.7
- Output I6.8
- Interface to short-term memory

General Functional Description

In function F26, the decision is made which drive to satisfy – but not the decision by what means it will be satisfied.[146] Therefore a subset of selectable goals is filtered out. Each selectable goal is valuated according to various factors. The existing possibilities of satisfying a drive represent one factor; here the drive representatives are valuated using quotas of affect and feelings. Other factors are social rules and the required effort for satisfaction determined by the reality check (F51).

All these factors result in an overall weighting of the selectable goals according to the reality principle. The goal which is most important to the agent, i.e. the one with the highest ultimate valuation, is selected.

Input

I6.1: Selectable goals
I6.3: Aims of drives, derived from the individual drives
I6.7: Feeling

Output

I6.13: Selectable goals

7.10.2 Function F52: Generation of Imaginary Actions

Function F52 is part of the selection track (Fig. 7.12) and possesses the following interfaces:

- Input I6.8
- Interface to short-term memory
- Environmental image

General Functional Description

Before an external action plan can be executed, various alternatives for its execution and the achievement of its goal must be mentally generated and tested. Here thinking means experimental action (hence the term “action in rehearsal”) on the basis of which a possible activity can be valuated because the imagined action sequence occurs without motor output (i.e. none of the results are passed on to F30 at this point): “Acting without acting is thinking” [Sol 04, p. 293].

Different action alternatives for the achievement of the incoming selectable goals under consideration of the environmental image are generated. If a selectable goal originates from perception, action is taken depending on memories and their respective valuations. To do this, actions are mentally simulated in F52 and then evaluated in F29 (see below).

Input

I6.8: Selectable goals

[146] Out of all the incoming drive wishes, the one that can be most efficiently satisfied in regard to the outside world, i.e. the one that provides the most pleasure, is chosen.

- Short-term memory
- Environmental image: perception for planning in space

Output

I6.13: Selectable goals with action plans.

7.10.3 Function F53: Reality Check Action Planning

Function F53 is part of the selection track (Fig. 7.12) and possesses the following interfaces:

- Input I6.9
- Output I6.10
- Short-term memory

General Functional Description

The imaginary actions generated in F52 are checked in F53 using factual knowledge under consideration of logical criteria to determine the action possibilities they afford and the requirements accompanying them. The result influences F29.

Input

I6.9: Selectable goals.

- Short-term memory – environmental image: perception for planning in space.

Output

- I6.10: Selectable goals with valuated action plans.

7.10.4 Function F29: Evaluation of Imaginary Actions

Function F29 is part of the selection track (Fig. 7.12) and possesses the following interfaces:

- Input I6.10
- Output I6.11
- Short-term memory

General Functional Description

One selectable goal is chosen as the planned goal according to criteria of pleasure maximization and unpleasure minimization. This planned goal is passed on; it and the other selectable goals with action plans are stored in short-term memory. Hence the state of the selectable goals and the planned goal are retained for a certain period of time.

Input

I6.10: Selectable goals.

- Short-term memory: current drive state

Output

I6.11: Planned goal with action

7.11 Imagination Track

The thought drafts not selected in the selection track are retained for use in the sense of remaining imagined. This means that they continue to exist (preconsciously) as fantasies and subsequently exert an unconscious influence on the events in the primary process (via the perception track). The condition for this continued ingress into the perception track is the re-transformation from the secondary to the primary process via the imagination track, which requires at least a removal of the word presentations – thereby also resulting in the loss of causal and temporal relations.

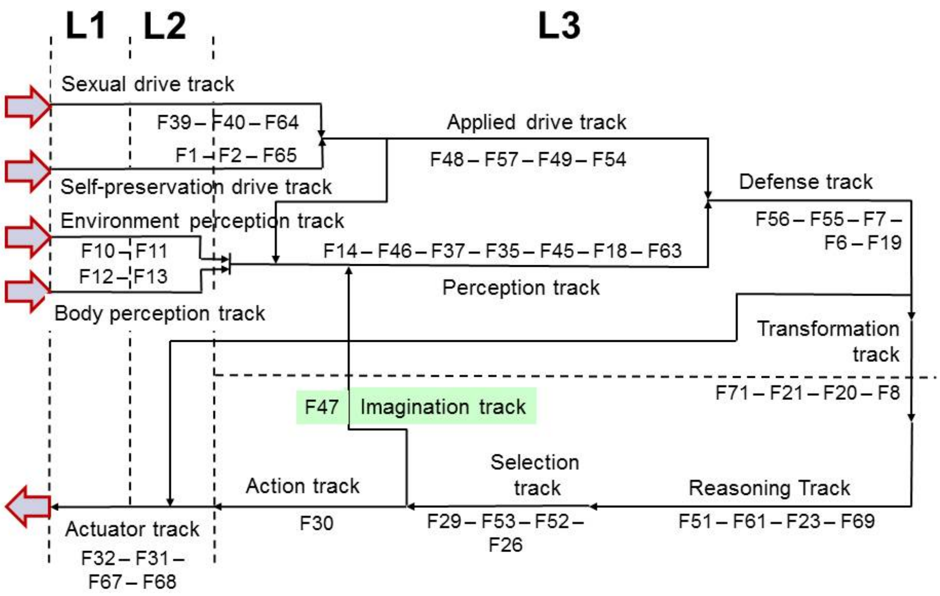

Fig. 7.13: Imagination track

7.11.1 Function F47: Conversion to Primary Process

Function F47 is part of the imagination track (Fig 7.13) and possesses the following interfaces:

- Input I6.11
- Output I5.19

General Functional Description

Contents are returned to the primary process as fantasies via the imagination track. In function F47, the primary process part of the data structure is separated from the secondary process part. This primary process part influences which memories are activated in F46.

Input

- I6.11: Planned goal

Output

- I5.19: Thing presentations of images/motions associated with the planned goal

7.12 Action Track

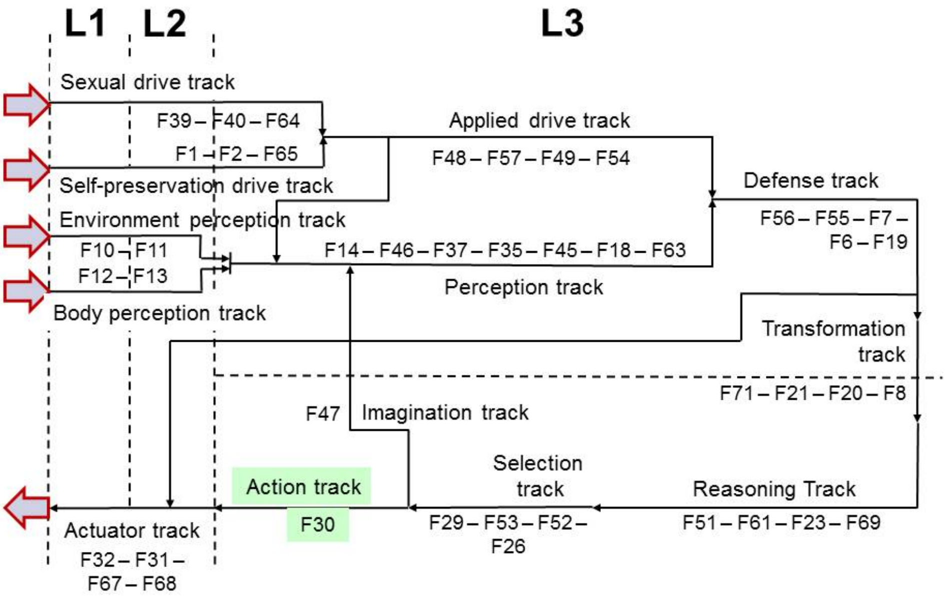

Fig. 7.14: Action track

The action that is ultimately chosen must be executed with the available bodily means, i.e. the psyche must use neurodesymbolization to transform the action sequence back into chemical and physical impulses and thus into real actions. The action track is responsible for sending the appropriate images and motions to the neurosymbolic layer.

7.12.1 Function F30: Mobility Control

Function F30 is part of the action track (Fig. 7.14) and possesses the following interfaces:

- Input I6.11
- Output I2.5
- Interface to long-term memory
- Interface to cyclic memory

General Functional Description

Function F30 separates heavily abstracted motor action sequences of the agent into many individual actions which are subsequently neurosymbolized to control the various muscles and glands of the body or mechanisms (motors, pumps, …) in a robot. In the current simulation of the SiMA project, this function is a dummy.

Input

I6.11: Planned goal with action

Output

I2.5: Images and motions

7.13 Actuator Track

In the actuator track, the images and motions from Layer 3, coming from the action track, are neurosymbolized in order to control the individual muscles and glands in Layer 1, the hardware. Layers 1 and 2 are implemented as dummies in the current SiMA simulation program.

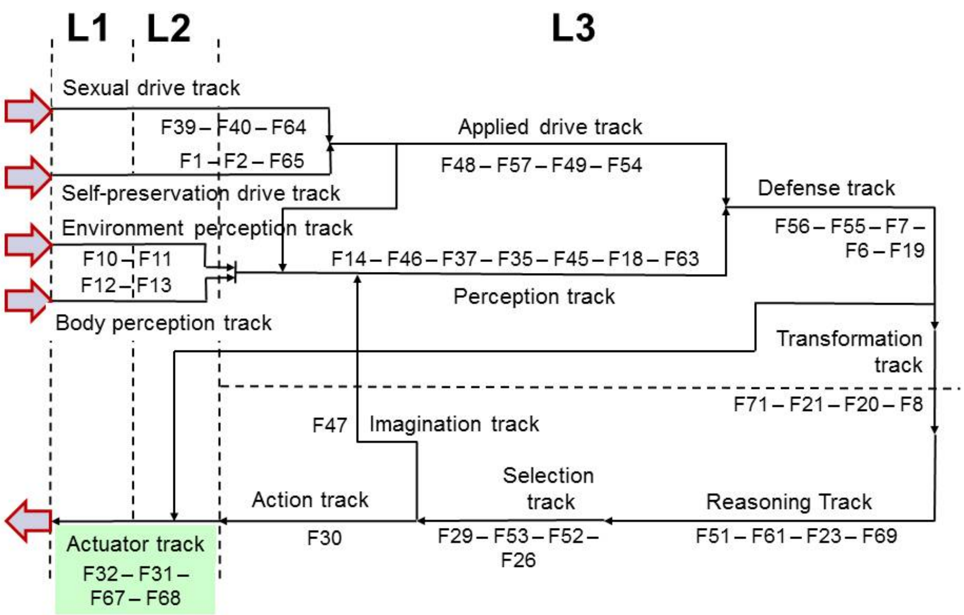

Fig. 7.15: Actuator track

7.13.1 Function F31: Neurosymbolization Action Commands

Function F31 is part of the “chain of command” to the bodily muscles and glands (Fig. 7.15) and possesses the following interfaces:

- Input I2.5
- Output I1.5

General Functional Description

Function F31 exclusively describes the neurosymbolization for the action commands to the muscles and glands in Layer 1. Part of this neurosymbolization is presumably hereditary, but the majority must be learned by humans, meaning that they must learn how to control their muscles in the early stages of their life. As this is a function of Layer 2, it is implemented merely as a dummy in connection with functions F32 (Actuators for muscles) and F68 (Actuators for glands) within the SiMA project.

Input

I2.5: Images and motions

Output

I1.5: Electrical signals

7.13.2 Function F67: Bodily Emotion Reaction

Function F67 is part of the chain of command to the bodily muscles and glands (Fig. 7.15) and possesses the following interfaces:

- Input I5.20
- Output I1.6
- Output I1.8

General Functional Description

Function F67 can be considered equivalent to F31 with specific characteristics in contrast to F31 which are not yet being implemented within the SiMA framework.

The current emotional state is reflected in the bodily state in that the currently present emotions influence the state of various organs. One emotion can influence several organs, just as one organ can influence several emotions. Depending on the respective organ states, different bodily forms of expression may subsequently ensue: for example, anger causes the pulse to quicken, which in turn causes the complexion to redden.

Input

I5.20: Basic and extended emotions

Output

I1.8: Electrical signals

7.13.3 Function F32: Actuators for Muscles

Function F32 is part of the chain of command to the muscles of the body (Fig. 7.15) and possesses the following interfaces:

- Input I1.5
- Output I0.5
- Personality parameter DP5

General Functional Description

Function F32 describes the hardware for activating the various muscles of the body, which is currently not within the scope of SiMA.

Input

I1.5: Electrical signals.

Output

I0.5: Electrical signals.

Interface Personality Parameter DP5

Personality-specific bodily parameters regarding the generation of various hormones.

7.13.4 Function F68: Actuators for Glands

Function F68 is part of the “chain of command” to the glands (Fig. 7.15) and possesses the following interfaces:

- Input I1.5
- Output I0.5
- Personality parameter DP5

General Functional Description

Function F68 describes the hardware for activating the various glands of the body, which is currently not within the scope of SiMA.

Input

I1.5: Electrical signals

Output

I0.5: Electrical signals

Interface to Personality Parameter DP5

Personality-specific bodily parameters regarding the generation of various hormones

8. Conclusion

The presented scientific report is the current documentation of the project SiMA. It is therefore constantly being expanded and modified, a process which also affects the goals of the project which are thus frequently adapted. This fact should be kept in mind while reading this chapter.

One specific feature of Chapter 8 must be emphasized: as stated above, the previous chapters of this scientific report were written during the active project process. Chapter 8, however, was written shortly before publication of the Report. For this reason the following Section 8.1 will provide a brief summary of the individual chapters, since new findings have entailed significant changes in the main focus of work on the SiMA project since the previous technical chapters were originally written.

8.1 Summary

The SiMA project clearly shows that the human brain can be very precisely examined from a natural scientific perspective. It also shows, however, that if one wishes to apply modern principles of modeling in computer engineering, one must understand and work with the principles of natural science. Chapter 3 explains the dangers that can arise from the use of inappropriate methods. Methods must always be chosen from the perspective of the desired application and validated accordingly.

Computer engineering is the first science dealing with entities – as they are referred to in information theory of computer engineering – which process, store and communicate data in large quantities, which forms the basis of the terminological definition of a computer. Computer engineering also takes up an exceptional position in vis-à-vis informatics, for it is not only tasked with developing and eventually producing entities in the sense of information technology, but must also provide the appropriate hardware. The latter is not necessarily the goal or responsibility of informatics. This means that computer engineering ultimately always has to deal with the laws of physics and base its work on them. However, this does not imply that physics must necessarily be the primary concern at the beginning of any development process. This was only the case in the early days of computer engineering; since then we have learned that one of the fundamental principles for the development of technical information systems is the top-down design principle which begins with a description of the behavior of the machine to be developed. This principle led to Chapter 4 of the presented scientific report, which represents the basis for validating the results of the SiMA project and provides the framework for determining whether the implementation of the model is working as intended. Therefore Chapter 4 itself is primarily founded in the knowledge of the involved psychoanalysts, which engineers can validate only in regard to its axiomatic and causal consistency and unambiguousness. This also means that the value and usefulness of the model ultimately depends on how robust and correct it is in terms of psychoanalysis. The simulation results might be based on a flawed *implementation* of a working model, but this is not a fundamental problem since validation of the results will quickly point out any such mistakes. If the implementation of the model is incorrect, variations of the simulation experiments will uncover the problems, as has happened over and over again in the course of the SiMA project. This is the great advantage of simulations: if they are based on an incorrect implementation or a lack of precision in the modeling of certain details, the corresponding error can be easily found and eliminated. Imprecision – or, to put it differently – inadequate detailing of the model repeatedly leads to problems and will continue to do so throughout the development process. An example of this is discussed in Chapter 5 in which the original functions of Freud's second topographical model – the id, the ego and the super-ego – are broken down according to the top-down principle until individual sub-functions are obtained which can then be examined and dealt with separately in order to answer the question of how they actually complete their tasks. Naturally, psychoanalysis finds it extremely difficult to scientifically investigate these sub-functions since their behavior may also affect the other sub-functions. It becomes an almost inhuman feat of intellect to contemplate the behavior of individual sub-functions while keeping in mind the overall functionality of the psyche, since the complexity of the relations grows exponentially as one goes into detail. It is therefore also not surprising that so many different and sometimes contradicting schools of thought have developed in psychoanalysis. Computer engineers are in a comparatively simple situation: they can examine the individual functions independently of the others, modifying them at will and testing the results. Simulation of the entire system then shows him what consequences his changes to a certain component have for the other components, for in his simulation program he can integrate monitoring functions everywhere to record and analyze every process in minute detail. This allows him to quickly recognize whether his adaptations made sense or not. Such technical results are far easier to validate, with the only barrier being the amount of effort invested. And this is the reason why simulation programs have now established themselves in all areas of natural science – except in psychoanalysis. It is to be hoped that projects like SiMA will help to further development in this field and make simulation programs accepted in psychoanalysis as well in the future, for it is only the problem of complexity that needs to be handled, reducing the problem to one of effort and hence of money. Simulation programs in the fields of architecture, biology, geodesy, computer architecture or meteorology (and many more) have consistently proven this fact.

Returning to the question of the required level of detailing in modeling, Chapter 5 with its overview of the modeling of the functions and sub-functions of the second topographical model makes two facts evident. Firstly, the essential factor for the model and the entire SiMA project is the clear axiomatic definition of terms. This takes up the vast majority of the entire time spent on the project, since no term from psychoanalysis, psychology or any other area can be used if it is defined only approximately or in contradiction with another term. It is not for nothing that many billions of Euros are spent worldwide on standardization (and thereby axiomatization) in technology. Nothing can be achieved in natural science and engineering without unambiguous terminology. The second major issue in SiMA which has taken up much time and will continue to do so are the further required steps towards refining the level of detail. An excellent example is the valuation of objects, goals etc. – cathexis in psychoanalytical terms. While Freud did not clearly differentiate between emotions and feelings, Damasio already understood that it was necessary to do so. In the course of the SiMA project, it has become clear that the psychic apparatus cannot be reasonably and efficiently modeled unless one introduces at least five different valuation quotas (mechanisms of cathexis): the quota of affect, the basic emotion, the extended emotion, the neutralized psychic intensity in the primary process and the feeling in the secondary process. And this is an important part of development in any scientific field: the deeper one wishes to go into detail, the more powerful the scientific language with its defined terminology must become. For this reason, the axiomatics tables in SiMA will continue to grow and be adapted in future.

Chapter 6 is quite rudimentary. It is intended to contain only the most basic information for engineers, thereby facilitating the familiarization of other research groups and engineers with the project and allowing them to easily adopt the simulation program (the project's goal is to put the simulation program into the public domain). Persons interested in more detailed technical information are encouraged to read the various dissertations, theses and other scientific publications hitherto published on SiMA.

Chapter 7 provides an overview of all functions currently included in the model. This information cannot of course suffice to understand them all in detail, but that is also not the intent. Each function includes a package of desiderata from existing dissertations: while the initial thesis papers in the project generally dealt with the model in its entirety, recent dissertations have been focusing more and more on certain sub-components and functional groups. Now would be the time for individual research projects to restrict themselves to individual functions, but this process unfortunately can no longer be undertaken under the direction of Dietrich. Nevertheless it must happen and will happen, in one way or another, for it is the only way to continue on this path towards analysis and improved understanding of the details of the psyche.

8.2 Vision

The previous section illustrates in what direction psychoanalytical theory will be heading in the future: like all the natural sciences it will require simulation as a tool, even if this sounds strange to some contemporary therapists. But the phenomenon is in no way new and has occurred in all areas which computer engineers approached with the intent of introducing simulation to them. 40 years ago, many architects laughed at them and claimed that simulation would scarcely play any sort of role in architecture, for the human brain cannot be replaced by a computer. This is not the intent of computer engineering, however – it merely wishes to support specialists with appropriate tools. Just like architecture cannot exist without architects, psychoanalysis will never do away with psychoanalysts. The simulation program is merely a tool, albeit a slightly more intelligent one than, say, a hammer.

What does this mean for psychoanalysis? The same thing it means for the other abovementioned areas. The architect who builds houses does not know the details of how his simulation programs work. He applies them. They are created by computer engineers, information scientists and architects specialized in their development. Hence like in other areas of natural science, there will be three main fields of responsibility in psychoanalysis, and brain research in general, in future: there will be people who create appropriate simulation tools, there will be researchers who continue to develop and refine the models used in psychoanalysis and brain research. And there will be a large group of "users" – psychoanalysts who ultimately help their patients using clinical methods. And the researchers and analysts will make use of the simulation programs in order to better and more easily understand the complex systems in psychoanalysis and brain research.

Once again, let us use the field of architecture as an example. A hundred years ago, a customer who ordered a house had to use their imagination (often quite a lot of it) to understand the designs his architect showed him. Using the results of 40 years of simulation program development, the customer can "walk through" such designs using 3D glasses today. Architecture, of course, is obviously not as complex as the human brain. But there is another important issue to emphasize: many modern buildings like the "Fondation Louis Vuitton", built in Paris by Frank Gehry, would never be possible without sophisticated simulation. As a brilliant architect, Gehry recognizes the signs of the times and uses the tools provided to him by computer engineering to their fullest potential.

The final visionary aspect to be pointed out is this: many people define psychoanalysis as a part of the *humanities*. SiMA however shows that even such a field can be analyzed and described in a natural scientific way. The results of further dissertations will be integrated into the next version (IV) of the scientific report; they deal with questions of ontology, language and learning. Thus we will increasingly permeate the area of the humanities, and eventually also that of the arts like music, and we will learn to handle them in natural scientific ways without the humanities having to lose their inherent beauty, their secrets and their perfection.

Appendices

(A) Axiomatics tables
(B) Literature
(C) Internet references
(D) Copied quotations
(E) Class and object diagrams

(A) Axiomatics in SiMA – Terminological Definitions

The theoretical prerequisites are put down from Section 3.2 (The Axiomatics of Bertrand Russell). Table 1 has been revised primarily by the psychoanalysts Georg Fodor, Klaus Doblhammer and Roman Widholm as well as the engineers Dietmar Dietrich and Samer Schaat and represents the most current results of extensive research and team meetings. One decisive aspect is that Dietmar Dietrich was able to obtain much experience in national and especially in international standardization committees like CENELEC, CEN, LNO, Profibus, etc. and has applied the methods developed there for the SiMA project. Based on these methods, great care was taken to ensure that no term contradicts any other terms, thus allowing the chosen terms to be viewed as axioms as per Bertrand Russell that form the foundation of the SiMA model. As any other axioms, they are not set in stone but must be constantly reassessed and amended – a process which is most sensibly and efficiently conducted in a team.

The terms must not be redefined or used in different ways within a scientific text. This is difficult, but it is a necessary condition to achieve a properly written scientific publication. It is for good reason that technical standards and their terms are secured in laws throughout Europe and the rest of the world, for it can have serious economic consequences if e.g. engineering terms in contracts are interpreted differently by the affected parties.

Within the SiMA project we differentiate primarily between two tables of terms, both of which are integrated into NPyG[147]. Excerpts from these two fundamental tables, one containing psychoanalytical terminological definitions, the other containing technical definitions, are shown in Table 1 and Table 2 below.

[147] NPyG: Natural scientific-psychoanalytical glossary, available for free (Excel spreadsheet) as a download on the SiMA project website.

Table 1: Psychoanalytical terminological definitions in the SiMA project (excerpt from NPyG)

Begriff / Term		Erläuterung / Description	
Abfuhr	discharge	…ist die Reduzierung von psychischer Intensität, die im psychischen Apparat vorhanden ist. Die reduzierte Menge entspricht in Folge dem Lustgewinn.	The reduction of psychic intensity within the psychic apparatus. The reduction amount equals the gain of pleasure.
Abwehr	defense	Ich-Funktion, die darüber entscheidet, ob und in welcher Form Triebwünsche oder Wahrnehmungen weiter zur Bewusstseinsfähigkeit verarbeiten werden dürfen.	Ego function that decides whether and in which form drive demands or perceptions are allowed to become conscious.
Abwehr-mechanis-mus	defense mechanism	Abwehrmechanismen sind Formen der Abwehr und werden unterschieden für Triebrepräsentanzen, Wahrnehmungen und Emotionen.	Defense mechanisms are a type of defense and are differentiated according to whether they apply to drives, perceptions or emotions.
Abwehr-schiene	defense track	… beschreibt jene Über-Ich und Ich-Funktionen, die zwischen Primär- und Sekundärprozess darüber entscheiden, ob im Zusammenhang mit Inhalten Konflikte bestehen und welche Inhalte bewusst werden dürfen.	Describes the super-ego functions and ego functions, distributed across the primary and secondary processes, that decide whether conflicts exist in regard to certain contents and which contents are allowed to become conscious.
Affekt	affect	Der Begriff wird nicht verwendet.	This term is not used in SiMA.
Affekt-betrag	quota of affect	Ein Potential, ein Bewertungsbetrag, der aus dem Trieb stammt und ein Äquivalent zur Triebspannung darstellt, der bewusste und unbewusste Inhalte besetzen und innerhalb der unbewussten psychischen Mechanismen verschoben werden kann. Durch Abfuhr von Affektbeträgen ensteht Lust. Affektbeträge sind die Basisgrößen für Emotionen und Gefühle.	A potential or evaluation quota originating from a drive and representing an equivalent to drive tension. It cathects conscious and unconscious contents and can be displaced within the unconscious mental mechanisms. The discharge of a quota of affect produces pleasure. Quotas of affect are the basic parameters of emotions and feelings.
Aggression	aggression	… ist eine Tendenz, die darauf abzielt, jemanden oder etwas zu schädigen, zu vernichten, zu zwingen oder zu demütigen.	A tendency aiming to damage, destroy, force or debase someone or something.
aggressive Triebkom-ponente	aggressive drive component	… sind im Zuge der Triebmischung jene Triebrepräsentanzen, deren Abfuhr zum Ziel haben, zu zerstören und zu fragmentieren. (Sie sind immer im Zusammenhang mit libidinösen Triebanteilen zu sehen.)	The drive representatives within the fusion of drive whose discharge is aimed at destruction and fragmentation (always existing in connection with libidinous drive components).
Akt	act	… ist ein zeitlicher Ablauf von Images und Szenarien. Er spielt sich aussschließlich im Sekundärprozess ab. Er ist die Basis für Nachdenken.	Describes the temporal sequence of images and motions. It only takes place within secondary process and is the foundation for reflection.
Angst	anxiety	… ist eine Emotion, die aus einer übermäßigen Unlustspannung entsteht. Vorerst ohne Objekt.	An emotion that originating from an excessive amount of unpleasure tension. Currently not associated with an object.
Anspruch, Aufforde-rung	demand	An den psychischen Apparat können grundsätzlich von drei Seiten Ansprüche gestellt werden: vom Es, vom Über-Ich und	There are three forms of demands affecting the mental apparatus: demands arising from the id, from the super-ego and from reality.

		von der Realität	
Assoziation	association	… beschreibt die gewichtete Verbindung zwischen unterschiedlichen neurosymbolischen oder psychischen Inhalten. Die Assoziationen können in der neurosymbolischen Ebene liegen oder im Primärprozess sein.	A weighted relation between different neurosymbolic or psychic contents. Associations exist on a neurosymbolic level or in the primary process.
Aufmerk-samkeit	attention	… bedeutet die gerichtete Wahrnehmung aufgrund von Überbesetzung des Wahrnehmungsobjekts	Attention describes the focused perception of an object by hypercathexis.
Aufmerk-samkeits-steuerung	focus of attention	… ist eine Ich-Funktion, die die aufmerksame Wahrnehmung steuert, um sie zu fokussieren und zu konzentrieren.	An ego function that guides attentive perception in order to focus and concentrate.
Aufwand, psychischer	psychic effort	… ist jene Unlust, die bei der Ausführung einer konkreten Handlung auf sich genommen wird. Er beeinflusst im Sinne des Lust-/Realitätsprinzips die Bewertungen wie Emotionen und Gefühle für Handlungsplanungen.	Describes the unpleasure accepted while conducting a concrete act. In the sense of the pleasure/unpleasure principle, it influences the valuation of emotions and feelings concerning the planning of acts.
Befriedi-gung	satisfaction	… ist ein Vorgang, der im Erreichen eines Triebziels, bzw. der Lösung eines Triebwunsches resultiert, indem durch Triebabfuhr Lust entsteht.	A process resulting from the achievement of an aim of drive, where pleasure is generated from the discharge of quotas of affect associated with the drive.
Befriedi-gungs-erinnerung	satisfaction memory	… gibt an, wie geeignet ein Objekt für die Befriedigung eines bestimmten Triebes ist. Dies entspricht der erinnerten Menge der Abfuhr von Affektbetrag mit diesem Objekt als Befriedigungsobjekt	Defines how useful an object is for the satisfaction of a certain drive. This equals the amount of discharge of quota of affect memorized for this object as an object of satisfaction.
Besetzung	cathexis	... bezeichnet den Bewertungsvorgang im Primärprozess, d. h. in der Besetzung findet die Zuweisung von Bewertungsgrößen an psychische Inhalte (von Affektbeträgen bis hin zu Emotionen) statt. Das Resultat ist die Zuordnung von psychischer Intensität zu psychischen Inhalten. Besetzungen werden durch die jeweils aktuelle Trieblage über Assoziationen zu Objekten und den damit assoziierten Objekten vorgenommen (spread-activation). Besetzungen können üblicherweise abgeführt werden. Im Sekundärvorgang gibt es auch Besetzungen, die fixiert bleiben und nicht vollständig abgeführt werden. (= Ich-Besetzungen, Selbst-Kerne).	The process of valuation on the level of the primary process, i.e. the assignment of valuation quotas (from quotas of affect to emotions) to psychic contents. The result of a cathexis is the allocation of psychic intensity to psychic content. Cathexis is conducted depending on the current state of drives through associations with objects and other objects associated with them (spread-activation). Cathexes can generally be discharged. In the secondary process certain cathexes can be fixed, resulting in the inability to completely discharge them (ego-cathexis, self-cores).
Bewertungs größe	valuation quota	Die Bewertungsgrößen in SiMA sind: 1. Affektbetrag, 2. neutralisierte Intensität, 3. Emotion, 4. erweitere Emotion, 5. Gefühl.	The valuation quotas existing in SiMA are: 1. quota of affect; 2. neutralized psychic intensity; 3. basic emotion; 4. extended emotion; 5. feeling.

Table 2: Technical terminological definitions within the SiMA project (excerpt from NPyG)

Term	**Description**
Actuator	Counterpart to the sensor. Used to interact with the environment by causing an action. Actuators are motors, contactors or, in the anatomical sense, muscles.
Agent, embodied, autonomous	Extends the attributes of software agents by embodiment, situatedness, and self-sufficiency. Therefore this agent must have a defined body (real or simulated). The main focus in embodied agents is the agent's interaction with the world. A very important design principle is the ecological balance – the internal processing capabilities have to match the complexity of the perceivable data.
Agent, Software ~	A software program capable of acting on behalf of a user or another program. The most important attributes of an agent are persistence, autonomy, flexibility (reactive, proactive, and social), adaptivity, distributedness, and mobility. The more attributes are implanted, the closer the agent comes to being a so called smart agent (or intelligent agent).
Application	A specific process, for example surveillance of a building, controlling the temperature in a room or controlling the gait of a robot. Each App on a smartphone is an application.
SiMA	Abbreviation for Artificial Recognition System, a research project at the Institute of Computer Technology, Vienna University of Technology, Austria. The project integrates neuropsychoanalytical principles into technical models. By initiating cooperation between psychoanalysts and engineers, the project aims at creating a functional model of the human psychic apparatus that can be implemented in a technical system.
Artificial intelligence	A technical research area that studies and applies the principles of intelligence of natural beings.
Artificial life	A simulation of embodied autonomous agents. They are placed within a simulated virtual environment. Artificial life simulations are closely related to social simulations. The focus of such simulations lies on understanding the information processing and social interactions of the agents.
Association	Describes any connection between psychic contents.
Automation	A general term for transferring work that was previously done by animals or humans to machines. Engineers create machines which make use of electrical, mechanical or other power to take over tasks (e. g. transport or restructuring of material).
Automation communication systems	Modern automation enables communication between machines. Today, communication is based on protocols which are usually organized in a hierarchically layered system. Automation communication systems are often called fieldbus systems.
Binary data	Data composed of only two symbols, for example "0" and "1". Data like letters, numbers, audio or video streams can be expressed by sequences of these two symbols. For example, the decimal number 9 can be represented by the sequence "1001".
Bionics	Translates biological principles into technical principles. The main idea is that evolution forced living organisms including fauna and flora to become highly optimized in order to survive. The principles and actual solutions developed by these living organisms are transferred into technical systems.

Body	A body is situated in a world and perceives the environment through its own sensors. Using its own actuators, it can move within the environment and is able to alter it to some extent. Additionally, it must have the ability to maintain all the necessary resources on its own. The body can be real or simulated.
Bottom-up design	Refers to a design method where design is based on existing solutions. The functionality of the existing solution is enhanced piece by piece in order to ultimately obtain a new system capable of solving other problems or executing other tasks. See also "Top-down design".
Building automation	A building automation system is a control system for a commercial building. Modern systems consist of a network of computerized nodes – fieldbus nodes – designed to monitor and control mechanical, lighting, security or entertainment systems in a building. The functionality of the entire system is called building automation. The most common applications today are control systems like heating, ventilation, air conditioning, or access control systems. See also "Home automation".
Chip design	Refers to the process of designing an integrated circuit. An integrated circuit consists of miniaturized electronic components built into an electrical network on a monolithic semiconductor substrate. Chip design is about designing a single chip solution with integrated functionality, achieved through digital or analog data processing or as mixed signals.
Cognitive science	An interdisciplinary field that employs findings from biology, neuroscience, psychology, psychoanalysis, philosophy, and computer science to study the mind, especially its cognitive functions such as thinking, problem solving, planning and, more generally, information processing functions.
Computer	A system which manipulates, memorizes and transfers data.
Computer system	A computer with peripheral devices.

(B) Literature

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[8] Page 40 in: http://www.zigbee.org/portals/0/documents/events/2012_03_08_JohnsonABCS.pdf

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[10] CB2: http://gizmodo.com/265392/cb2-japanese-robot-child

(D) Copied Quotations

These quotations are referenced in the main text body using references of the form *Z<number>*.

Z1: [Freud, GW XV, 188] „Der Fortschritt in der wissenschaftlichen Arbeit vollzieht sich ganz ähnlich wie in einer Analyse. Man bringt Erwartungen in die Arbeit mit, aber man muß sie zurückdrängen. Man erfährt durch die Beobachtung bald hier, bald dort etwas Neues, die Stücke passen zunächst nicht zusammen. Man stellt Vermutungen auf, macht Hilfskonstruktionen, die man zurücknimmt, wenn sie sich nicht bestätigen, man braucht viel Geduld, Bereitschaft für alle Möglichkeiten, verzichtet auf frühe Überzeugungen, um nicht unter deren Zwang neue, unerwartete Momente zu übersehen, und am Ende lohnt sich der ganze Aufwand, die zerstreuten Funde fügen sich zusammen, man gewinnt den Einblick in ein ganzes Stück des seelischen Geschehens, hat die Aufgabe erledigt und ist nun frei für die nächste. Nur die Hilfe, die das Experiment der Forschung leistet, muß man in der Analyse entbehren."

Z2: [Freud, GW XVII, 80f] „Es kann dabei [in der Psychoanalyse, Anm. von Klaus Doblhammer] nicht ohne neue Annahmen und die Schöpfung neuer Begriffe abgehen, aber diese sind nicht als Zeugnisse unserer Verlegenheit zu verachten, sondern als Bereicherungen der Wissenschaft einzuschätzen, haben Anspruch auf denselben Annäherungswert wie die entsprechenden intellektuellen Hilfskonstruktionen in anderen Naturwissenschaften, erwarten ihre Abänderungen, Berichtigungen und feinere Bestimmung durch gehäufte und gesiebte Erfahrung. Es entspricht dann auch ganz unserer Erwartung, dass die Grundbegriffe der neuen Wissenschaft, ihre Prinzipien (Trieb, nervöse Energie u.a.) auf längere Zeit so unbestimmt bleiben wie die der älteren Wissenschaften (Kraft, Masse, Anziehung)."

Z3: [Freud, GW XIV, 108] „Ich betonte dort, daß die psychoanalytische Auffassung vom Verhältnis des bewußten Ichs zum übermächtigen Unbewußten eine schwere Kränkung der menschlichen Eigenliebe bedeute, die ich die psychologische nannte und an die biologische Kränkung durch die Deszendenzlehre und die frühere kosmologische durch die Entdeckung des Kopernikus anreihte."

Z4: Freud, S. (1900). VII: ZUR PSYCHOLOGIE DER TRAUMVORGÄNGE. GESAMMELTE WERKE: II/III, 616: „Das Unbewußte ist das eigentlich reale Psychische, uns nach seiner inneren Natur so unbekannt wie das Reale der Außenwelt, und uns durch die Daten des Bewußtseins ebenso unvollständig gegeben wie die Außenwelt durch die Angaben unserer Sinnesorgane."

Z5: Freud, S. (1915). DAS UNBEWUSSTE. GESAMMELTE WERKE: X, 280: „Ich schlage vor, daß es eine metapsychologische Darstellung genannt werden soll, wenn es uns gelingt, einen psychischen Vorgang nach seinen dynamischen, topischen und ökonomischen Beziehungen zu beschreiben."

Z6: Freud, S. (1938). ABRISS DER PSYCHOANALYSE. GESAMMELTE WERKE: XVII, 81: „Wir haben also den psychischen Vorgängen drei Qualitäten zugeschrieben, sie sind entweder bewusst, vorbewusst oder unbewusst. Die Scheidung zwischen den drei Klassen von Inhalten, welche diese Qualitäten tragen, ist weder eine absolute noch eine permanente. Das was vorbewusst ist, wird, wie wir sehen, ohne unser Zutun bewusst, das Unbewusste kann durch unsere Bemühung bewusst gemacht werden, wobei wir die Empfindung haben dürfen, dass wir oft sehr starke Widerstände überwinden."

Z7: Freud, S. (1910). ÜBER PSYCHOANALYSE. GESAMMELTE WERKE: VIII, 22: „Wir leiten die psychische Spaltung nicht von einer angeborenen Unzulänglichkeit des seelischen Apparates zur Synthese ab, sondern erklären sie dynamisch durch den Konflikt widerstreitender Seelenkräfte, erkennen in ihr das Ergebnis eines aktiven Sträubens der beiden psychischen Gruppierungen gegeneinander. … Die Situation des psychischen Konflikts ist ja eine überaus häufige, …“

Z8: Freud, S. (1915). DIE VERDRÄNGUNG. GESAMMELTE WERKE: X, 254: „Für dieses andere Element der psychischen Repräsentanz hat sich der Name Affektbetrag eingebürgert; es entspricht dem Triebe, insofern er sich von der Vorstellung abgelöst hat und einen seiner Quantität gemäßen Ausdruck in Vorgängen findet, welche als Affekte der Empfindung bemerkbar werden.“

Z9: Freud, S. (1917). XXII. VORLESUNG: GESICHTSPUNKTE DER ENTWICKLUNG UND REGRESSION. ÄTIOLOGIE. GESAMMELTE WERKE: XI, 368: „Nur soviel darf man sich getrauen zu behaupten, daß die Lust irgendwie an die Verringerung, Herabsetzung oder das Erlöschen der im Seelenapparat waltenden Reizmenge gebunden ist, die Unlust aber an eine Erhöhung derselben.“

Z10: Laplanche/Pontalis (1973). Das Vokabular der Psychoanalyse, 131: „Im Primärprozess wird die Energie frei oder beweglich genannt, soweit sie auf die schnellste und direkteste Weise der Abfuhr zustrebt; im Sekundärvorgang ist sie gebunden, soweit ihr Streben nach Abfuhr aufgehalten und kontrolliert wird.“

Z11: [Fre 15, S. 273]: „Aber alle Versuche, von da aus eine Lokalisation der seelischen Vorgänge zu erraten, alle Bemühungen, die Vorstellungen i n Nervenzellen aufgespeichert zu denken und die Erregungen auf Nervenfasern wandern zu lassen, sind gründlich gescheitert. Dasselbe Schicksal würde einer Lehre bevorstehen, die etwa den anatomischen Ort des Systems Bw, der bewußten Seelentätigkeit, in der Hirnrinde erkennen und die unbewußten Vorgänge in die subkortikalen Hirnpartien versetzen wollte. Es klafft hier eine Lücke, deren Ausfüllung derzeit nicht möglich ist, auch nicht zu den Aufgaben der Psychologie gehört. Unsere psychische Topik hat vorläufig nichts mit der Anatomie zu tun; sie bezieht sich auf Regionen des seelischen Apparats, wo immer sie i m Körper gelegen sein mögen, und nicht auf anatomische Örtlichkeiten. Unsere Arbeit ist also in dieser Hinsicht frei und darf nach ihren eigenen Bedürfnissen vorgehen.“

Z12. [Fre 35]: „Ich halte Ihnen allen vor, daß Sie nicht schärfer und reinlicher zwischen Psychischem und Biologischem unterscheiden, daß Sie einen durchgehenden Parallelismus zwischen beiden Reihen herstellen wollen und unbedenklich in dieser Absicht psychische Tatbestände erfinden, die nicht nachweisbar sind und daß Sie dabei unzweifelhaft vieles formal für reaktiv und regressiv erklären müssen. Diese Vorwürfe bleiben natürlich dunkel. Ich möchte nur noch betonen, daß wir die Psa. ebenso unabhängig von der Biologie zu halten haben wie von der Anatomie und Physiologie bisher, die Sexualbiologie scheint ja auf zwei Substanzen hinzuführen, die sich gegenseitig anziehen. Wir haben nur eine Libido, die sich männlich gebärdet.“

(E) Class and Object Diagrams

In order to illustrate the relationships between classes and objects, class and object diagrams in a self-chosen format based on UML (unified modeling language [Bal 05]) are used in SiMA. Fig. A1 shows the three node types in this format: concrete classes, abstract classes and objects. For concrete classes and objects, the relevant properties and, if appropriate, concrete values for properties can be specified in addition. Abstract classes are placeholders that represent various concrete classes. Which concrete classes can be used in place of specific abstract classes is determined by specialization as described in the next paragraph.

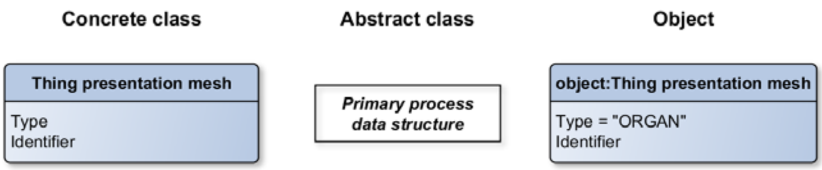

Fig. A1: Node types

Fig. A2 shows the connection types of the diagram format. Relationships between different classes or between classes and objects are represented by a single uninterrupted line. Specializations are represented by an uninterrupted line with an empty arrow head at their end. Specializations determine which concrete classes can be used in place of specific abstract classes.

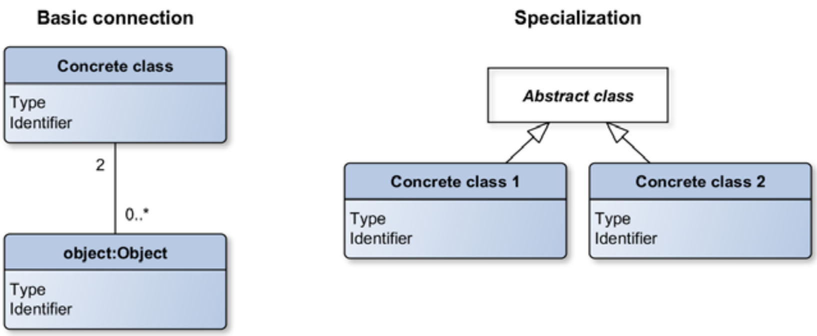

Fig. A2: Connection types

Connections can feature multiplicities specified at the respective ends of each connection as can be seen in Fig. A2 (left-hand side) for basic connections. A multiplicity at either end of a connection specifies how many instances of the respective class or object can be involved in the connection. Possible multiplicities are:

0..1	0 or 1 instance
1	exactly 1 instance
0..*	0 or more instances
1..*	1 or more instances

Hence the example on the left-hand side of Fig. A2 should be interpreted as follows: 1 instance of the concrete class is associated with 0 or more objects, while each object is associated with exactly 2 instances of the concrete class.