The Current State of Psychoanalytically-Inspired AI

A Holistic and Unitary Model of Human Psychic Processes

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***Abstract*—Complexity of technology is constantly increasing; for the field of automation this means that economic considerations dictate a need for corresponding measures. Artificial intelligence boasts noteworthy successes in this area; however, its achievements appear modest when compared to the faculties of human intelligence. This paper will demonstrate that a new modeling approach is required via possibilities offered by the mindset and tools of computer technology, thereby demonstrating why a psychoanalytic approach seems sensible and necessary. The paramount goal of the research introduced in the following is a formal approach to describing the human psyche based on the neuro-symbolic and neuronal functional layers. Questions associated with this approach include: To what extent can the psychoanalytic model be confirmed by computer technology and the possibility of simulation? To what extent is an axiomatically developed terminology in psychoanalysis a prerequisite for the better integration of the natural-scientific way of thinking in psychoanalysis?**

The paper is based on the results of several fundamental research projects within the framework of ARS (Artificial Recognition System) which were funded in part nationally and in part by the EU.

Keywords—Cognitive Automation; Artificial General Intelligence; Cognitive Architecture; Artificial Intelligence

I. Environment and State of the Art

The complexity[1] of technical processes and their description is increasing considerably, and thought must be given as to how to control such systems efficiently. Successful control depends to a high degree on the ability to recognize process relationships, analyze scenarios, achieve precise parameterization of information nodes (data processing units, embedded systems, etc.) at reasonable costs, and letting decisions be made automatically by computers on the basis of complex contexts, thereby automating information cycles as thoroughly as possible.

Examples could be robotic units integrated into complex processes (in a certain process environment like a household or hospital), or as the simple case in [1]: a child is in the kitchen, a pot of water is boiling on the stovetop and no adult is nearby. Why are there not already “simple” recognition systems (analyzers) for such scenarios in household robots which could understand the potential danger and sound an alarm? Why do we not have robots that monitor airports without human assistance, e.g. in order to identify unattended baggage which poses a potential threat (the goal of one of the EU projects which the project discussed in this paper is built around [2])?

Apparently the current limits of feasibility are reached relatively quickly when machines (i.e. computers) are supposed to analyze situations or make decisions. It is therefore imperative to push these boundaries by implementing new approaches. In the following, a possible bionic solution will be presented which was first introduced internationally by the author in [3] and is based on activities by the associated institute since the year 1999. During this time, a large number of scientific papers about the project ARS (Artificial Recognition System)[2] have been completed and published – an excellent overview of these publications can be found in [7] – but only recently have significant principal research questions been identified clearly enough being able to begin answering them. Some of these aspects will be illustrated in this paper which addresses the following questions: What importance do statistically described psychic processes have? What does the introduction of a layered model mean? What is the significance of the differentiation between functional model and data model? How can the functional model of the psyche be specified on the basis of psychoanalytical theories? These questions will be answered in the following.

II. Boundary Conditions

A new approach implies a certain divergence from accustomed concepts. The reasons and new boundary conditions for the necessary departure from prior ways of thinking will thus be delineated first, for they will lead to a dramatic paradigm shift in artificial intelligence as well as in psychoanalysis.

A. Hierarchical Model and Top-Down Design

Computer engineers are used to working with hierarchically layered models and models of distributed systems (on the topic of layered models, see Fig. 1, left side). In computer engineering, the bottommost layer 1 contains the hardware and its functions; above this come the functions of the operating system (layer 2); finally, layer 3 holds software functions of applications like Microsoft Word or Excel. Furthermore, computer engineers also follow the general definition of a computer, according to which a data processing unit (a computer) is a

[1] The term complexity – in contrast to “complicatedness” – is used to indicate that a process cannot be comprehensively described because its internal correlations are not yet fully understood. Statistical methods are often used as a “stopgap” solution to better describe such complex processes; they may easily lead to misinterpretations, however. Chapter 2 will deal with these problems in more detail.

[2] http://ars.ict.tuwien.ac.at

system in which data are manipulated, stored and transferred. Seen from this perspective and using the definition of internationally well-known neurologist Alexander Lurija, who defined three layers[3] for the human brain [4], one may come to the first rough representation seen on the right side in Fig. 1. Its structure corresponds to that of the computer on the left side: the lowest layer 1 describes the hardware, i.e. the neuronal networks. Above this is the functional layer 2 of neuro-symbolism which transforms the data coming from the hardware into symbols (and vice versa). The topmost layer 3 comprises the functional system of the psyche, which is further subdivided into the primary and secondary process. The model presentation of the ARS project in Chapter 4 will show that such a layered model must be further differentiated and multi-dimensionally described.

Word, Excel	Layer 3	Psyche
Operation system	Layer 2	Neurosymbolics
Hardware	Layer 1	Hardware / Neural networks

Fig. 1. : Possible abstraction layers of a computer. (left: an artificial computer, right: a biological computer)

If one accepts the notion that the brain is a data-processing system which controls the "process" of a human being (thus forming an inseparable unit with a human), and if one further accepts that software is essentially hardware which is merely subject to a different form of description[4], then one must conclude that neuronal networks achieve precisely the function defined above – manipulation, storage, and transferring of information. Thus the hardware of an artificial computer is merely a different technology from that of the "bio-computer", but the information theory of the three layers can be applied equally to both systems[5].

Going by the results in [5], which divide AI (Artificial Intelligence) into four generations (symbolic AI, statistical AI, behavior-based AI, and now emotion-based AI), it becomes obvious that the hitherto followed path to understanding and emulating the principles of the human brain represent a bottom-up method: it was first attempted to work out the lower layers (neuronal layers, symbolization, …), then behavior-based considerations were added – i.e. the body was integrated –, and today we have finally arrived at attempts to incorporate concepts like "emotions" and "feelings" in artificial intelligence.

However, if engineers are supposed to develop machines which behave with similar "intelligence" to that of humans, it will be unavoidable to not only deal with human behavior, but to investigate what it is that actually makes a human. What functions are at work in the topmost layer 3, the psyche? What places mankind in its unique role as human being, and why are humans mentally superior to all other animals? How can we determine and define the interplay of human psychic functions?

This is a great challenge for the natural scientist and engineer who has had to acquire detailed knowledge of the information theory of complex functional information units with the advent of the computer and must continually develop that knowledge even now. Functional information units are the components of a computer; they produce the behavior of the machine. Based on this theoretical consideration, it should be possible to develop a (functional) model of the human mental apparatus which explains human behavior and which also allows simulation and subsequently emulation, i.e. integration into a robot.

Here we return to the principle of the hierarchical model, which has become an accepted method of description in computer and communication technology. For example, layered models may be defined in which the individual layers are assigned different tasks, services, etc. and which are designed following the top-down principle: one begins the specification and development process at the topmost layer, possibly dividing it into sub-layers, and continues downwards, finally ending up at the lowest functional unit, e.g. as in the ISO/OSI model in communication technology or the Y-diagram by Gajski-Walter for digital chip design in the production of computers. Thus when beginning the development of a new (artificial) computer from scratch, one should begin at the topmost level – the application – and continue using the top-down approach which has become the norm in automation and chip design.

For the "bio-computer" in Fig. 1, this means that development should begin not with the neuronal networks, but instead – using the human brain as the archetype – with the conscious processes of the mental apparatus. Such a procedure would accentuate several important aspects at once: first, it would emphasize a monistic conviction and natural-science-based view of the brain as a control system without any mystical properties. Second, such a model would allow the deduction of various boundary conditions hitherto unappreciated in the field of artificial intelligence – which the following section will deal with.

B. Statistical Methods

Various physiological and mental control loops exist within humans (therefore, according to Fig. 1 and Fig. 2, they are active across all layers). Based on the assumption that the purpose of any control loop may be either to stabilize or destabilize behavior, and that the various control loops can influence each other, it quickly becomes clear that statements regarding one individual control loop in the complex overall process are only possible if a concrete model for the overall process and therefore for each sub-process is used as a basis. In other words: if a word processing program like Microsoft Word

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[3] Lurija had no access to the information theory of today. According to the sophisticated examinations conducted during the development of the ARS model, his "layered model" with three layers was a mixture of functional and level-oriented model on the one hand and topologically and locally oriented model on the other. As this approach does not conform to the strict rules for layered models of today's information theory in computer technology, Lurija's model had to be adapted for use in ARS.

[4] Software can ultimately be made visible using electric fields (even though this requires great effort). The microprogram of a CPU, situated between hardware and software in the layered model, can therefore be described in terms of either of these concepts, with each description requiring a different type of observation. This shows that the differentiation between software and hardware is strictly one of the required tools, and both are ultimately physics – meaning, in effect, hardware.

[5] Of course the individual layers on the left and right in Fig. 1 cannot be equated to one another. However, the model structure with functional layers and interfaces between them is the same for both.

suddenly exhibits strange behavior, statistical analysis will not help to determine the cause thereof if one has no concrete knowledge of the correlations between the various functional layers of the computer down to the hardware level. One cannot determine whether the malfunction is due to a problem in the BIOS (basic input/output system), the operating system or the application Microsoft Word itself. Even worse, an error in the upper layers may cause a reaction in the lower layers (or vice versa) which may mask the actual problem, as layers may attempt to compensate for malfunctions in other layers.

Applied to the human brain, this means that if one observes human behavior using statistical methods without knowledge of the internal structure, feedbacks and workings of the mental apparatus – as is the case with the human brain[6] –, precise statements about sources of error or influences are not possible because other active layers may modify or compensate such erroneous or erratic behavior or even convert it into its opposite.

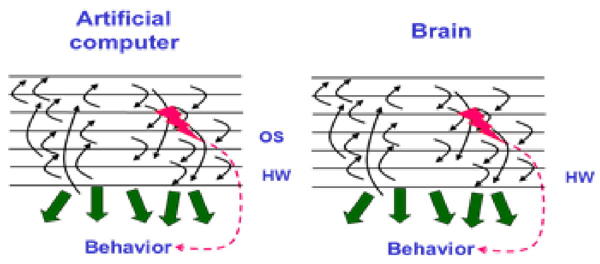

Fig. 2. : Layer functionality (OS: operating system; HW: hardware).

This basic problem of the observability of processes can also be explained using the communication model of a hierarchical layered process from information theory as seen in Fig. 3. We assume a process A (of function a) in the secondary process of the psyche which is to be analyzed in connection with a process M (of function m) in the neuronal layer. Of course, the statistical correlation between A and M could be studied using EEG or MRI scans. However, this would not result in the direct causal connection of any processes and functions between A and M and their influence would not be measured or even identified. Thus statistical analysis may assist in the understanding of mental processes or identification of abnormal processes, but it is patently useless for model synthesis by engineers as done in the project ARS. The development of such a model requires knowledge about the individual processes and their interdependence to be provided by psychoanalysis and brain research.

This illustrates why a computer engineer (or a chip designer) can make little use of statements about behavior based on statistical methods – like many statements in psychology, but not in psychoanalysis.

An engineer needs a functional and consistent model which explains the causal relationships between individual processes. Artificial intelligence research, however, is often based on methods of behavior research – which in turn relies heavily on statistics, see examples in [6]. These methods allow behavior to be simulated and possibly emulated under certain circumstances, but they do not describe the functional correlation between individual processes which may result in entirely different behavior under different circumstances.

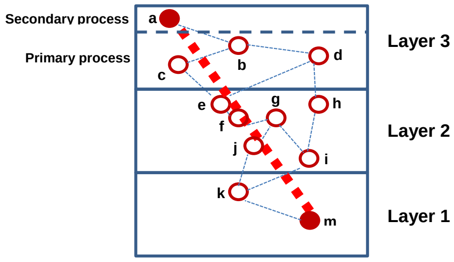

Fig. 3. : Process coupling of process A (of function a) with process M via various other processes B, C, .., K (of the processes b, c, .. , k) over three layers 1 to 3.

C. Interdisciplinarity

Psychoanalysts and neuropsychoanalysts are notably absent in scientific publications on robotics and AI, even though they are eminent experts on the psyche. It is also noteworthy that while suggestions have occasionally been made to integrate psychoanalysis and engineering, the first serious efforts to this end were undertaken in 2000, e.g. in [3]. It is however policy in the scientific world that all significant scientific results from around the world must be considered when conducting (and publishing) research – this is one of the foundations of science per se. Therefore, if the 4th generation of AI is to introduce concepts like "emotions" and "feelings", then experts from psychoanalysis, psychology and pedagogics must be included in any serious associated scientific work.

The reverse is also true, of course: why does psychoanalysis not integrate the scientific results from computer science and information technology, i.e. information theory, in its own scientific studies and endeavors? Why do both sides practically ignore each other? Psychoanalysis was founded before World War I and is internationally recognized[7] as a science, as is information technology. The only possible conclusion must be that research teams must focus much more on interdisciplinarity in the future.

III. Why Neuropsychoanalysis?

Psychoanalysis deals with conscious and unconscious information and data, i.e. (as per Fig. 1) with the topmost layer 3 of the brain – the psyche. It is therefore the only science attempt on developing a comprehensive and integrated model conception of the psyche by using the first and especially the second topographical model. The authors know of no other such model, as explained in detail in [1] and mentioned briefly in Chapter 2 of this paper.

For the layers below the psyche, i.e. the neurosymbolic layer 2 and the hardware layer 1, neurosymbolic and neurological models may be used. It must be noted, however, that practically no models exist in neurology or psychology for layer 2, while layer 1, the layer of neuronal networks, has been exten-

[6] It must once again be emphasized at this point that the term brain encompasses all three layers, i.e. the neuronal, neuro-symbolic and psychic layers, in the terminology of the ARS project.

[7] Psychoanalytical models have become increasingly interesting for natural science (e.g. neurology [9]). Opinions regarding the scientific nature of psychoanalysis differ. For example, [14] criticizes the methodological state of psychoanalysis, but Stegmüller [15] disagrees.

sively simulated. The neurosymbolic layer 2 thus represents a major gap which the international neuropsychoanalytic association NPSA is attempting to bridge (Neuropsychoanalysis[8]). As co-founder Mark Solms shows, several of Freud's theories have been confirmed on the basis of neurological studies [9]. The researchers at the NPSA assume that the theories of neurology and psychoanalysis can be unified into a consistent model of the brain. With this notion, we computer engineers agree – however we do not believe that neurological and psychoanalytical explanations must inevitably lead to the same result, for the two fields describe different layers in the brain. As neurologists, psychologists and psychoanalysts do not work with the layered model of information theory [1], this fact is often not taken into consideration, which leads to solutions being sought where – in the opinion of the authors – they cannot exist. There is a good reason why computer scientists and engineers differentiate between hardware and software (i.e. upper and lower layers), for software is not written on the basis of the laws of physics, but on those of information theory, which was developed mostly in the last few decades by electrical and computer scientists and engineers and is described using other means.

Several questions that are of interest to the NPSA can be answered using the functional layered model of information theory. Two examples shall be presented here:

How can layer 2, the neurosymbolic layer, be researched? According to Damasio [10], at the lowest level there are 12 billion neurons and about 1000 times as many synapses. How can such numbers of connections be analyzed in a living human being? It will certainly not be possible in the next few years using network analysis. Similarly, a computer engineer would never attempt to analyze all of the transistors in a computer to find out how "higher" programs like Word or Excel work. There is also no point in searching for an explanation of the immediate connections between these two functional layers.

It is equally impossible to look down through the primary process from above, i.e. via the secondary psychic processes – through layer 3 into layer 2. Firstly, one cannot "look into" a human's third layer (this is only possible via physics and neurosymbolic functions, i.e. via layers 1 and 2), and secondly, one could consider oneself fortunate enough if one were able to develop a model for the unconscious processes and data (the primary process) by analyzing the data in the secondary process. This is the job of psychoanalysts. Such a model of the primary process cannot be comprehensively defined for a concrete person (especially its data contents) – it will always remain a relatively "rough" concept. Furthermore, humans lack linguistic and other means of expression for experiences close to the sensory level – "deeply" unconscious data. The reason for the absence of such expressions is simple: not all data necessarily make it to the secondary process, thus they are never assigned a word representation by the secondary process and cannot be articulated in our conscious language. Freud [13] writes: „How are we to arrive at a knowledge of the unconscious? It is of course only as something conscious that we know it, after it has undergone transformation or translation into something conscious." The day-to-day experience of the psychoanalyst shows that such translations are indeed possible.

Development of a model of layer 2 is not an unsolvable problem for the computer engineer, however, as evidenced by Fig. 5 and inclusion of the considerations in [10].

As a model conception of the psyche (layer 3) is defined by psychoanalytic knowledge, it must be possible to define "Interface 2" in Fig. 5 based on the functional requirements of layer 3. The same applies to "Interface 1" coming from below – which was already attempted by Velik in [8]. Once these two interfaces have been defined, the neurosymbolic model for layer 2 can be developed based on the functional requirements of layers 1 and 3. This results in 3 functional models which build on each other and together form an integrated and comprehensive model of the brain. The relationship between the psyche and the neurons can thus be described quite adequately in an indirect fashion, but their direct connection remains undefined. Information theory dictates that no intermediate layers may be ignored while searching for correlations between functions in different layers.

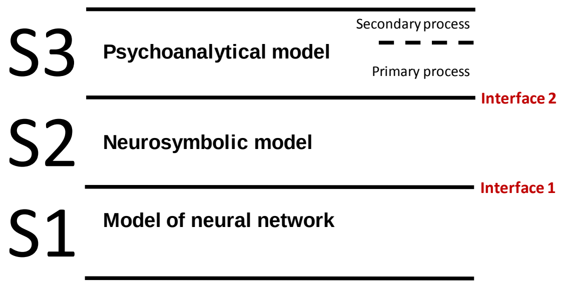

Fig. 4. : Hierarchy definition according to Lurija [4], separated into areas of more or less model knowledge. S1 to S3: layers 1 to 3.

A second example for the answering of psychoanalytical questions is a problem pointed out by Freud: in [11], Freud mentions that he could see no way of consolidating his first and second topographical model. For the computer engineer, the second topographical model represents a functional model with the functions Id, Ego and Super-ego, while the first topographical model is a data model, i.e. it describes whether data are conscious, preconscious or unconscious. This means that the first topographical model is a behavioral description of the data or information within the psyche and does not describe their functionality; it also means that "the conscious", "the preconscious" and "the unconscious" as such do not exist. From the perspective of computer science, the definitions therefore need only be differentiated somewhat more: Id, Ego and Super-Ego are functions in which data are manipulated, stored and transferred – and these data may be conscious, preconscious or unconscious. Freud was of course unaware of this differentiation made by modern information theory.

IV. The Psychoanalytical Model

The first publication about the ARS project explained that the brain must be viewed as a hierarchical system [3], a notion supported by Lurija [4], Solms [9] and Damasio [10]. As described in Chapter 3 above, Velik defined the neurosymbolic layer, which sits above the neuronal layer, according to this principle in [8]. The psyche represents the third layer and is defined by the ARS project using a psychoanalytical model.

[8] www.neuropsa.org.uk

This layer should be viewed as a distributed system [1], symbolized by the sub-functions[9] depicted on the left side of Fig. 5.

The model is a functional one in which psychoanalytic concepts are used to describe how a motivational impulse (computer engineers use the term input value) leads to the emergence of a wish, then to a decision and action plan, and finally to an action itself, as illustrated in TABLE I. and Fig. 6.

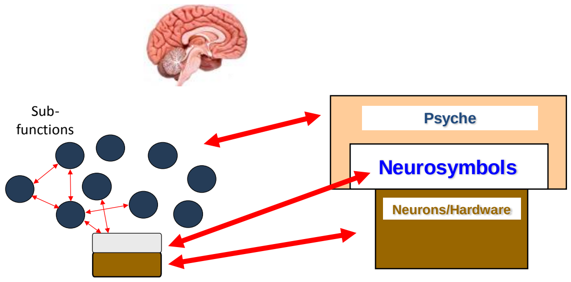

Fig. 5. : Hierarchical model with distributed system of the psyche.

The mental apparatus, i.e. the psyche, is divided into the instances Ego, Id, and Super-Ego [12]. The latter two impose demands which the Ego must synthesize while factoring in outside reality.

The Id comprises drive demands (see Fig. 6: drive track)[10] which are derived from bodily and physiological conditions as well as from sexual (sexual track) and self-preservation (self-preservation track) demands. Perception of the world outside the body (environment perception track) occurs via the functions F10 and F11. Perception of the person's own body (which, according to Freud, is part of the outside world from the perspective of the psyche[11]) occurs via the functions F12 and F13. Data from the environment perception functions is consolidated and processed via the perception track.

In addition to the four basic inputs – sexual, self-preservation, environment perception and body perception – there exists a fifth one which is a feedback input from the secondary process via function F47 (fantasy track). This represents fantasies from the preconscious.

All these input data initiate associations via memory traces which lead to bodily tensions by transformation into drive representations and the definition of source, aim and object of the respective drive. The defined source is perceived as the cause of the bodily tension; the aim signifies the action which will allow the psyche to discharge the tension; and the object is the thing with which satisfaction may be achieved [13]. At this level, it is an imagined (hallucinated) object and has nothing to do with a perceived or perceivable object in the outside world. The magnitude of the drive tension is represented by the quota of affect which is used to assign significance to the object and things associated with it, i.e. to psychically "activate" them.

The Super-Ego is the source of internalized rules, values and norms, which themselves impose demands on the psyche while also antagonizing specific drive and perception contents.

TABLE I. LIST OF TRACKS WITH ASSOCIATED FUNCTIONS

Sexual drive track
F39 Seeking system (libido source); F40 Neurosymbolization of libido F64; Partial sexual drives
Drive track
F48 Accumulation of affects for drives; F57 Memory traces for drives; F49 Primal repression for drives; F54 Emersion of blocked drive content; F56 Desexualization / neutralization; F63 Composition of emotions
Self-preservation drive track
F1 Sensors for metabolism; F2 Neurosymbolization of needs; F65 Partial self-preservation drives
Environment perception track
F10 Sensors for the environment; F11 Neurosymbolization of the environment
Body perception track
F12 Sensors for the body; F13 Neurosymbolization of the body
Perception track
F14 External perception; F46 Fusion with memory traces; F37 Primal repression for perception; F35 Emersion of blocked content; F45 Libido discharge; F18 Composition of affects for perception
Defense track
F55 Super-Ego proactive; F7 Super-Ego reactive; F6 Defense mechanisms for drives; F19 Defense mechanisms for perception
Transformation track
F21 Transformation to secondary process for perception; F20 Composition of feelings; F8 Transformation to secondary process for drive wishes; F61 Localization; F66 Speech production
Selection of desire & demand track
F26 Decision making; F51 Reality check wish fulfillment
Selection track
F52 Generation of imaginary actions; F29 Evaluation of imaginary actions; F53 Reality check action planning
Imagination track
F47 Transformation to primary process
Action track
F30 Motility control; F31 Neurodesymbolization action commands; F32 Actuators

The multiplicity of data leads to conflicts between the Id (drive and perception tracks at the top left in Fig. 6), the Super-Ego and reality, i.e. between the internal and external perception. In a mature psyche[12], these conflicts are resolved by the Ego via the use of defense mechanisms. The central concepts in the evaluation of these conflicts are the quota of affects in the drive track, the emotions in the defense track and the feelings in the secondary process.

Only thing-presentations exist in the primary process. During the transition from primary to secondary process, word-presentations are assigned to these thing-presentations, thereby causing the contents to become temporally, logically and conceptually structured[13]. In the entire secondary process the two

[9] The layered model described here is a functional layered model, meaning it is described in terms of the functions in the individual layers. Naturally, each layer may be further split up into sub-functions, etc.

[10] The sub-functions of the psyche and the two lower layers are designated Fx, where "x" is a number (see Table 1). Individual sub-functions, here simply termed "functions", cannot be described in detail in this paper, but are explained in full in [7].

[11] In contrast to the inside world of purely psychic conception.

[12] For reasons of simplicity, the ARS project initially deals only with the mature psyche of a grown-up.

[13] This allows e.g. a thing-conception association complex regarding a desired food product – which has passed the defense mechanisms and is also pre-

presentations appear in association, but data processing occurs only via the word-conceptions.

Incoming data from the sensors and any data associated with them must be filtered after transition into the secondary process, which is achieved by an attention control mechanism in the functions of the selection track for desire & demand; here the current concrete wishes are determined. The selection track then takes care of planning, which always includes the simulation of several possibilities according to Solms [9], and executes the action it determines to be optimal in the situation. Naturally, this is strongly dependent on what can be achieved in reality, wherefore a mature human must possess appropriate knowledge of the circumstances of the outside reality, its possibilities and limits.

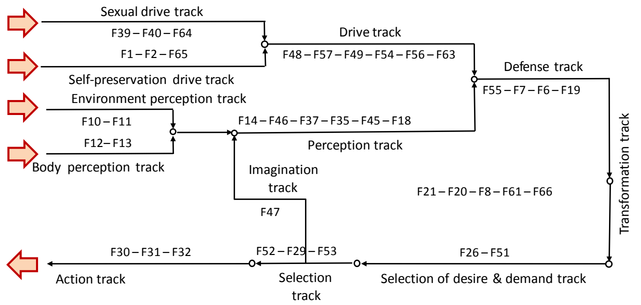

Fig. 6. : Data flow in layer 3 (psyche); primary process above the imagination track, secondary process below.

V. Further Course of Action

The modeling achieved so far is tested and validated in exhaustive practical experiments. A simulation platform consisting of a virtual environment and software agents (called ARSini) is developed to allow use-cases to be simulated. The complete model of the brain is integrated into each of the software agents, forcing them to make decisions and take actions according to the demands imposed by their body and the environment.

The simulation also follows a top-down approach: the use-case specified by the psychoanalysts in the research team forms the "top", i.e. the starting point, and thereby determines the requirements for everything else. The agents are individualized, i.e. they each receive their own history and parameterization (attributes like memory traces, Super-Ego contents, defense mechanisms, drive fixations, (primal) repressed contents, desexualization value, etc.), which represents going "down" in the approach.

This top-down approach from psychoanalysis results in a complex system – although one must be aware that not even close to all the functions of the psyche or the human brain have been implemented here. For example, the hormonal system or the learning principles in the various functions F1 to F66 in Fig. 6 are not yet modeled. Thus the current concept should be viewed as a first draft for the simulation of the brain. In a next step, the realized simulations will need to be analyzed according to principles of psychological experimentation. As is the case with the European research project SENSE [2], the ultimate goal is to derive control systems and decision-making systems from this model in order to create application-specific solutions.

It is beyond doubt that natural scientific validation of psychoanalytic theories on the functioning of the psyche will also be possible as a result.

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sent in the perception track – to be connected with the word-conceptions [schnitzel] and [eat].