Way to go for AI

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***Abstract*—Taking up future challenges of AI has brought researchers to look for new scientific domains that can provide models, methods and solutions. Some of us found them in neuropsychoanalysis, a rather young discipline that brought together neurology and psychoanalysis. The authors believe that engineers can gain a lot from getting acquainted with the concepts and methods of this discipline, however uncommon they may sometimes appear to an engineer. This paper sums up some of the relevant ideas that build the foundation of cooperation between scientists from both fields. It also gives an overview of the current ongoing research and the expectations for the future.**

Keywords: artificial intelligence, neuropsychoanalysis, mind and body, modeling

I. Introduction

Expectations have risen for what has been called Artificial Intelligence in the last decades. While we are perfectly able to reach the planets of our solar system and refine theories about when and how the universe began, the apparently simpler problems of everyday life are still to be solved. Machines taking over chores like cleaning the apartment or walking the dog are yet to come. While CPU power keeps increasing exponentially, we still could not create machines that are sufficiently capable of dealing with the everyday environment that we live in. AI is not the challenge, it is being challenged. A machine with fancy abilities like human-like perception and motor skills would instantly create huge markets for new innovative products.

We see basically three possibilities, how this technological leap forward can come about and we have decided to go along with one of them. Either we are able to extend the abilities for data processing and pattern recognition like it is used today in data mining. Improvements would yield algorithms that are able to extract relevant information not from digital data stored in computers, but from the physical world that surrounds us.

Or we look at material sciences as another possibility; starting from matter itself, where bionic research has already contributed a lot to technical state of the art – be it a dirt resistant surface taken from the lotus flower or intelligent tire profiles with improved friction just like the paw of a polar bear. Ongoing research in nanotechnology could finally yield intelligent, regenerative materials that would become the basic building blocks. Based on these we could create systems that are able to store and transport information as well as energy and transform energy into motility.

The third discipline – which is the one that the authors have selected – is the combination of psychoanalysis, neurology, and engineering. It will be explained in detail in the following chapter.

II. Psychoanalysis, Neurology, Engineering – Crossing borders

This discipline has on the one hand long traditions, but is nevertheless a rather young field. The combination of neurology, which has the organic brain as its focus, and psychoanalysis, which concentrates both theory and therapy on the human mind, has in the last decade created *neuropsychoanalysis*. Both disciplines tackle the same thing from two sides – and we intentionally leave out the idea of a human mind that is metaphysical and thus escapes scientific explanations. The human mind is grounded in the brain and body, just like a software program is grounded in the hardware that executes it. It cannot exist without its main organ, the brain and the body that encloses it.

Being able to create a model of the human mind that can not only help to cure human patients, but that allows engineers to build machines can create the breakthrough that will let truly intelligent machines come into existence. Even if not all the phenomena of the mind like, for example, consciousness are subject to technical implementation today – and will certainly not be for the next decades – a consistent and functional model of the mind can thoroughly shape the way engineers think and thus the way they create machines.

There is a possible shortcut that could appear feasible: if the human mind is so complicated, why not substitute it by a simplified model? Examples are the subsumption architecture by Rodney Brooks [1] or BDI (Believe, Desire, Intention) by Michael Bratman [2] and developed by Georgeff and Ingrand [3]. Such architectures are much simpler and thus easier to implement. However, the authors nevertheless take the human mind as a blueprint for our enterprise, because it is the best prototype available. While it is challenging to translate it into technical terms because of its complexities, the support we get from our fellow scientists in psychoanalysis ensures that we do not fall short of our goal and end up with a system that is based on an insufficient model. Psychoanalysis gives us a complete model, explaining abilities that are today far from being built in a technical system, but whatever we achieve today will still fit into the model and will not become obsolete.

On the path of interdisciplinary cooperation of neurology, psychoanalysis and engineering we stumble upon the work of Sigmund Freud, who has pioneered in modeling the mind. His work is used and refined until today. Even more, concepts that Freud created without being able to prove them organically – that is, in the neurological tissue of the brain – have now found

new support in neuropsychoanalysis; for example, the neurotransmitter dopamine shows close resemblance to the pleasure seeking system that Freud called *libido*. The benefit of such bilateral explanations for the same mechanism is clearly on the side of engineers: Combining organic explanations of the brain with psychological explanations of the mind yield an excellent functional model of what engineers want to build.

At first Freud himself was a neurologist before he became the founder of psychoanalysis later on. In the 1890s he decided to abandon the development of neurological explanations of psychic processes. The reason for this was the very inadequate state of neurological understanding at the time. Freud knew that it was too early for a reasonable alliance between psychoanalysis and neurology. Neurology first had to evolve from a mechanical science operating with terms of fixed functions and localities. Neurology had to turn away from the so-called "localizationism" to a more dynamic analysis of neurological difficulties in terms of functional systems, which are distributed in the brain and interact with each other. A pioneer of such an approach was A.R. Lurija in the Soviet Union. He developed the new discipline of neuropsychology: he reformed the "old" neurology and worked out the foundation for an interdisciplinary complement of psychoanalysis and neurology [4]. Nowadays Mark Solms – who is the founder of the "International Neuro-Psychoanalysis Society" – approaches the problem from two sides: he makes detailed neuropsychological examinations of patients with brain damage on the one hand and takes them into psychoanalytic treatment on the other hand. Afterwards he compares the knowledge of the two approaches with each other to bring the mechanisms of the brain and the inner world of the patients together [5].

The neuro-psychoanalysis is a very young discipline, which has developed methods joining the knowledge of psychoanalysis with the knowledge of neurology. The ARS project will be dependent on the actual and future knowledge of neuro-psychoanalysis in the course of the proceeding modelling. The psychoanalytical theories describe a very abstract level of mental processes, the neurological theories apply to the base level of cellular processes. In between there is a gap the neuro-psychoanalysis promises to close.

Proper modeling is the key to a good system, but is a difficult task in our case. The goal is to get a functional model and not a model that allows to mimic the behavior. We want to illustrate this by using an example: when starting a journey it appears reasonable not to rush out in a hurry, but instead prepare well and – shortly before leaving – take a short break to let everything pass by once again. Is everything packed? Do I have all necessary documents? Are the windows closed? Will someone feed the cat? A good way to take this break is to sit down for a moment and reflect upon all relevant things. In some cultures in Eastern Europe people therefore said that it is good to sit down before you start a journey. Over time this has become detached from its original reason and has become superstition. People say that it brings good luck to sit down before a journey. So they sit down, wait a bit and then go for travel. This example shows one important thing: seen from the outside two persons would behave identically; both sit down, wait a bit and then go for their journey. Actually, one of them actually thinks through the upcoming journey, the other one is doing it for good luck. From the outside their behavior cannot be told apart.

This is critical for our goal to model the human mind. If we base the model merely on observations of human beings and their behavior, we end up with a system that is able to "wait, then travel" – but without performing the functions that make this behavior useful. Instead we want to build a system that possesses the necessary functions and performs them correctly – which (ideally) yields a system that shows the same behavior. Sigmund Freud started to build a functional model of the mind and we use this model (the second topographical model, which is explained in more detail in Section IV) to design a technical system (described in Section V). It is worth noting that also Freud had to start with observing behavior, since the mind is not accessible from the inside by an external observer; but he used his observations to identify functions of the mind instead of explaining symptomatic behavior of his patients.

The way the engineers look at the mind has changed over time. Today there are still many different opinions how to describe the mind. Former mechanical models, which try to explain phenomena of the mind by flows of water or flows of energy have largely been abandoned, since they oversimplify the complexity. The approach that the authors have chosen is different: we understand the mind as an information processing system, thus information storage and processing are the key questions that need to be answered. The technical translation of the psychic apparatus is a system that receives information from its sensors, which perceive both the outside world and the internal milieu of the body; it controls its actuators that influence both the outside world and the internal milieu of the body.

In an interdisciplinary basic research project, finding a common language is crucial. Ambiguities have to be identified and solved. For example, in psychoanalysis the term "energy" refers to a property of a piece of information which reflects its importance at the moment. This is incompatible with "energy" as defined by physics. In this special case, the ambiguity was solved by adding the prefix "psychic" when using "energy" in a psychoanalytical context [6, p. 36].

Another source of misunderstandings are concepts alien or uncommon to one or the other scientific field. For example, the psychoanalytical description of the second topic model of Sigmund Freud does not clearly differentiate between behavior, function, and property. Computer scientists have a clear understanding of these terms within their domain. The problem is, that the mind is not a Von Neumann machine and thereafter it is difficult to identify which observed pattern is a function or a behavior, or if it is only a property of the underlying processes. To produce a clear and concise model of the human mental apparatus using technical terms is the core task of such an interdisciplinary project.

III. Oddities on the Way to Useful Machines

Engineers have a goal in mind, before they start designing a machine; it shall wash clothes, transport people or estimate future weather conditions. Whatever is necessary to build this machine is integrated; each component contributes to the overall functionality of the machine. Most developments are done by innovations, which extend or combine existing

solutions to get an improved product. For reasons of efficiency as little as possible is added or modified to get the new product.

When pushing forward AI and attempting to get machines with human-like abilities, we have to leave the scheme of innovation and go for a different approach. The way to the solution is not straight forward, but requires us to consider the elements that make up a human mind – and brought it into being in the first place. The consequence is that we have to build a system that consists of many parts, which may seem unnecessary for achieving our goal. However, we believe that this step is vital to be able to advance. Much work has to be put into the design of apparently marginal components, because only the existence of these components supports the technical implementation of the model of the psychic apparatus. We will now examine these prerequisites for successful translation by looking at the reasons why the human mind possesses its abilities in the first place.

A. Body

The reason for our complex mind is the complex body in which it is embedded and the complex environment, in which the body exists. The development of mind and body has always happened in parallel. The body, or the internal milieu, is the primary reason for a mind to exist. The mind has to mediate between the requirements of the body and the environment. For the technical appliance this means that we cannot design a technical mind without simultaneously designing some kind of technical body. But we have to be careful not to oversimplify: today a technical system usually relies on some kind of hardware and is equipped with sensors and actuators to interact with the environment. To take this setup as the technical body is not reasonable, since the hardware does not state any requirements that the software can fulfill (e.g. loss of energy) and because the hardware is much too simple for a complex mind to carry it. The technical body that we envision is a source of requirements, which the mind has to satisfy, e.g. by interacting with the environment or with other entities. The design of the body strongly shapes the kind of mind that we get – and it will in the first approach not be related to any useful function of the system; it is merely necessary to support the mind.

B. Mind

The mind itself is unconscious, but we are able to perceive it consciously by looking inwards. The capacity for introspection and self-awareness is one of the most important properties of the mind. We perceive the "me" through introspection. It can also be perceived through the external senses as a physical body with organs and physiological processes. Body and mind are different agencies and bodily processes are not mental. Thus the mind itself is unconscious. Nothing else than our perceptions of these processes are conscious. These perceptions come in two forms, the bodily one and the mental one. Therefore the mind is bound up with the first-person observational perspective. This perspective is generated by our inner awareness of living in a physical body and it is the only perspective from which everything we experience bands together in a self-awareness. A computer can only have consciousness, if it is fitted with the capacity for self-awareness grounded in a visceral body.

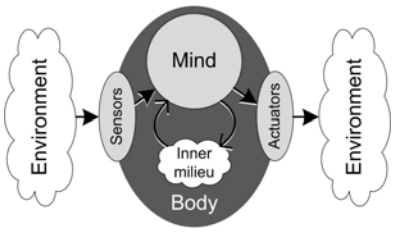

Figure 1. Fig. 1 Environment - Body - Mind

Figure 1 shows how the mind, the body, and the environment are interconnected. The body is situated within an environment. Within it are the mind and the inner milieu situated. The mind can sense and act upon the inner milieu and – using the bodies sensors and actuators – upon the environment.

C. Design

A fascinating "clash of cultures" is the discussion on how to build a machine with human-like abilities. While engineers start working from the machine side, defining the overall function (which is most questionable at the current state), and breaking it into subsystems and modules, which can be implemented one after the other. In the process one never gets to work with the complete machine, only when all work is done, the machine is operable and can be used. Psychoanalysis does not suffer from the need of creating anything, before working on it – the person, who is subject of their research is already equipped with a working mind that is embedded into a body. This makes one of the most interesting questions for engineers hard to pose: How can we break it down into smaller pieces? The complexity of the whole system is not easily comprehensible, therefore modularity seems to be the way to go: define subsystems with manageable functionality and define the interfaces between the subsystems. This quest appears dubious to psychoanalysts, since the subject of research can usually not be taken apart. Nevertheless, the great contribution of Sigmund Freud was to do exactly this – take apart the human mind and create a functional model, which defines subsystems that cooperate. Still, when digging down into the functional model and searching for strict limits between one subsystem and the other or for interfaces between the systems it turns out that – strictly speaking –everything is connected to everything.

We have to see that modular systems are necessary to handle complexity and because we currently do not have a better approach that allows us to describe the human mind as a whole. If possible, we should give up the attempt to integrate one module after another and try to do it all at once. A possible direction is to integrate the control unit (the technical counterpart of the human mind) into a body and let this embodied agent exist as a whole. By defining goals that give a measure for the quality of the agent, we could use genetic algorithms to mutate both control unit and mind to improve the agent. This way we do not have to cope with single modules, but we improve the overall performance of the agent as a whole. Such an approach can be found in [7]; agents consist of geometrical shapes and exist in a virtual environment with simplified physics. They have to achieve different goals, e.g. moving as far as possible. After several generations of mutations development has yielded agents that can be

considered able to move. Unfortunately, the attempt to model a more complex mind and body would create a considerable amount of parameters that would have to be optimized, which currently does not promise to converge to a working agent.

We have stated earlier that the technical translation of the mind is an information processing system that receives information from it sensors and controls its actuators. This is the subtopic of perception that has been tackled in various ways and also yielded good results in technical systems today, e.g. recognition systems or visual person tracking (for example project SENSE[1]). Motility also has made progress in robotics, aside of simple designs which can already be used in everyday households like the Roomba[2] robot that is able to clean floors we also have highly advanced mobile robots like Hondas Asimo[3], who is able to walk on two feet. Perception is usually oriented towards the environment: systems shall be able to observe public places and track people automatically; they shall recognize the face of persons or other biometric data. In the approach we take there is a second side of perception that is most important: just like we argue that a mind cannot exist without a body, it is clear that the body influences the mind. It does so by the second side of perception, which is oriented towards the body. The technical body of the system, its state and its requirements are perceived by the mind and it is the foremost goal of the system to keep the body in homeostasis and supply it with everything that the body needs. Increased requirements of the body force the mind to achieve more complex goals and we see this mechanism as one of the key issues to a successful intelligent system.

There are a lot of barriers that could prevent effective communication between psychoanalysis and the engineering sciences. A considerable barrier is the fact that both sciences deal with different kinds of reality.

Empirical reality is always a mixture of logical different types of reality. The nomological reality is homogeneous and constantly the same. The autopoietic reality is heterogeneous, in a permanent movement and transformation, managing itself.

Nomological reality is comprised with denotative theories. These theories are able to reduce the reality in an algorithmic way without any deficit of logic. The autopoietic reality has to be dealt with connotative theories. These theories have flexible terms, which are able to communicate logical structure and empirical specialness. Connotative theories have particular problems. To perform efficiently they have to possess capacities which complicate the balance and stabilization of concepts. Furthermore the structure of autopoietic reality produces the possibility of heterogeneous approaches. And there is another “risk”. Connotative theories depend on their use and their conditions. Thus institutional contexts and their dynamics systematically influence the structure and the dynamic of a theory. There is a crossover of the knowledge and the scientific object and that is why the effects of self-reflection add to the act of knowledge. In this case connotative theories are part of the reality they describe. Especially psychoanalysis is a self-reflective theory. It has to use a specific kind of connotative theory for coping with the autopoiesis of its topic.

[1] http://www.sense-ist.org
[2] http://www.irobot.com
[3] http://world.honda.com/asimo

This is not a defect, but a character of this kind of theory. Generally speaking science and psychoanalysis deal with different kinds of reality for which reason they develop different kinds of theories: on the one hand denotative theories, on the other hand connotative theories. This circumstance is a crucial reason for a lot of difficulties and misunderstandings in the interdisciplinary dialogues between psychoanalysis and the engineering sciences.

For engineers, who have been trained in natural sciences it is an inconvenient thought that a science like psychoanalysis, which deals with autopoietic reality shall contribute a model that builds the base for a technical system. Engineers are used to objectivity, which allows for reproducible results of experiments and descriptions that do not depend on the individual that creates the description. However, the concept of subjectivity and subjective experience are essential for psychoanalysis. Whatever a subject experiences strongly depends on its own history and its current psychic state. For the technical translation of the mind subjectivity implies that the system – again – strongly depends on its body and its internal milieu, which again is the base for the system’s state and furthermore that mind and body cannot be separated; the system has to be understood as a whole, consisting of mind and body.

IV. Model of the Mind

Based on the experiences of the development of a former model, the decision was made to use Sigmund Freud´s second topographical model [8] for the new ARS model. So the new model is based upon Freud´s original work and publications closely related to it. We decided in favour of the second topographical model because its design is consistent with the top-down design. The top-down approach is clearly immanent in metapsychological concepts. When Freud set forth the concepts of Id, Ego and Super-Ego and then described their respective contents and functions, his method corresponds to a top-down approach. The approach of the top-down design starts the modeling process at the topmost level with a simple concept of the subject. In the next level down this concept is divided into more detailed subparts. The process of dividing a part into more detailed subparts is repeated until the desired degree of detail has been reached. This design technique is similar to Freud´s development of the second topographical model, because he divided the mind into different parts according to a top-down approach.

While Freud made a distinction between the agencies unconscious, preconscious and conscious in the first topographical model he differentiates between the agencies Id, Ego and Super-Ego in the second topographical model. The Id involves everything that psychically represents the drives. Because of this the properties of the Id are the same like Freud attributed to the system unconscious in the first topographical model. The concept of the Ego comprises all organizing, integrative and synthetic functions of the mind and the Freudian concept of the Super-Ego consists of prohibitive/imperative and ideal functions.

The top-down approach as depicted in Figure 2 is used to analyze the second topographical model and to design a decision unit for autonomous agents. The first layer shows the functional division of the Brain module into the *Sensor*

interface, the *Actuator interface* and the *Psychic apparatus* one layer beneath it. The *Sensor interface* module gathers information from the environment by the body´s sensor system. The incoming data is passed on to the module *Psychic apparatus* that generates resulting control decisions. The *Actuator interface* forms the connection between the *Psychic apparatus* and the mechanical body element. The central part of the model is given by the *Psychic apparatus.*

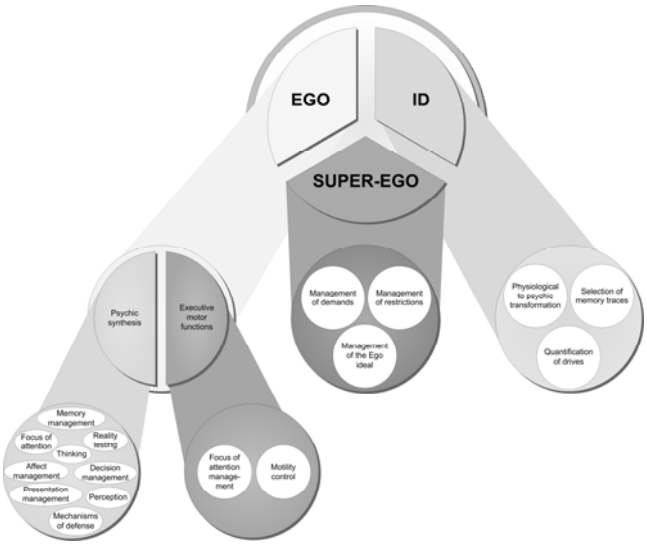

Figure 2. Fig. 2 Top-Down Designed Model of the Mind

The sub modules of the *Psychic apparatus* are the *Ego-, Id- and Super-Ego-module*. The *Ego* is able to receive environmental information as well as to send information to it. The *Id* receives bodily information. The *Super-Ego* disposes of an interface to the *Ego* that it receives environmental information from. All communication within the *Psychic apparatus* is centered in the *Ego.*

In the following, the modules *Ego, Id* and *Super-Ego* and their functions are described.

A. *Id*

The Id is grouped into three modules named: Physiological to psychic transformation, Selection of memory traces and Quantification of drives. The module Physiological to psychic transformation means the conversion of physiological stimuli to psychic representatives, that are affects and presentations. The module Quantification of drives means that drive representatives are cathected and on this way evaluated. The module Selection of memory traces deals with the generation of memory traces and their cathexis.

B. *Super-Ego*

The Super-Ego is divided into three modules – the Management of demands, the Management of restrictions and the Management of the Ego ideal. The Management of demands module organizes demands based on social norms and the Management of restrictions module organizes restrictions on behavior and thinking defined by the social background. The Module Management of the Ego ideal handles the ideal image of oneself.

C. *Ego*

The *Ego* module is divided into two modules, which are entitled as *Psychic synthesis* and *Executive motor functions*. The functions of the *Psychic synthesis* module deal with the mediation between *Id* and *Super-Ego* on the basis of perceived outer world conditions.

1) *Psychic synthesis*

Within the Psychic synthesis module nine modules are defined which are named Perception, Focus of attention, Affect management, Reality testing, Presentation management, Memory management, Decision management, Mechanisms of defense and Thinking.

The *Perception module* is a pool for outer and inner world information. The module *Focus of attention* defines search for a required object in the outer world which corresponds to an activated presentation due to a drive demand. The module *Affect management* forms the affects as drive representatives and forwards them to the designated *Ego modules.*

According to Freud the module *Presentation management* differentiates between two types of presentations – thing presentations and word presentations. This module organizes the facilitations between thing presentations and word presentations.

The main task of the module *Thinking* is the structuring and the organization of the contents of primary processes. The organizational process proceeds on the base of culturally influenced logic and results in the conversion to the secondary process.

The module *Reality testing* is used to differentiate between inner presentations and outer reality, between imagination and reality.

The module *Memory management* organizes the memory traces the Ego is dealing with and the *Decision management* module handles the conflicts which occur within the *Psychic apparatus*. Therefore the incoming information, which is received from *the Reality testing, Perception* and *Super-Ego modules*, is analyzed.

The *Mechanisms of defense* module represses upcoming conflicts if the current environmental condition and the *Super-Ego* do not allow a drive discharge.

2) *Executive motor functions*

The module *Executive motor functions* define the control of perception and motor activity. This module is subdivides into *Focus of attention management* and *Motility control.* The *Focus of attention management* determines necessary environmental information by controlling the *Focus of attention module* of *Psychic synthesis*.

The *Motility control module* is used to control the body´s motility and motor driven actions.

V. THE SOFTWARE

As stated above, the mental apparatus has to be developed together with a specific body in mind. While the goal of our research is to implement a universal decision making unit, we have to take this fact into account. Thus, as an intermediate step, a virtual life simulation platform is developed – the

Bubble Family Game [6, pp.65-67]. The main agents or life forms within it are the so called Bubbles. They roam their world in search for food and social interaction. Threats to the Bubbles are carnivores and other Bubbles.

Each agent is equipped with a body. It is the container for a complex inner milieu consisting of a stomach, messenger systems, and a nervous system. The stomach needs different kinds of nutrition. Dependent on the diet, the system can generate more or less energy. To interact with the environment the Bubbles have sensors (e.g. vision, acoustic, olfactory) and actuators (movement, carrying object, consuming nutrition, etc.).

The Bubbles perform tasks like search for food, collect food, defend each other, and search for new interesting areas. To give them the possibility for social interaction, they are able to dance, present each other gifts, and to help hunting large prey. These actions can also be performed together with other Bubbles, but there is always the possibility that they will start to fight.

Several different objects are placed into the environment. They are forming the landscape. Using them, Bubbles can identify previously visited places, define where their home is, the borders of their territory, etc.

The advantage of this approach is that we can take many analogies from the human body and human societies. Psychoanalysis describes a human mind situated within a human body acting in a human society. Abstraction from psychoanalytical theories to technical systems like building automation systems can be postponed until a working implementation within these agents exists. Using this simulator it is possible to study the implementation of the bubble mind. The authors are well aware that at the current stage the abilities of the implementation may be surmounted by implementations of classical AI systems, which may be much more feasible to collect energy or find the shortest path between two points. However, we are confident that the framework model is capable of extensions that go beyond abilities of existing implementations.

VI. Conclusion

Artificial intelligence needs a push forward in order to create the next generation of machines. We see neuropsychoanalysis as the right way to achieve this leap in development. While we want machines to be useful and support us in our daily life, we have seen that we will not achieve this goal directly, but we have to make a detour by defining not only an agent's mind, but also its body.

The next step in building up the model of the mind is to define an interface for each module which specifies what kind of information and in which form this information has to be transferred. Of course it is not sufficient, that affects are sent from Id to the Ego; we need the precise definition of the information that is exchanged, otherwise no interpretation would be possible.

We will soon reach the stage where we can observe a working implementation of the psychic apparatus' translation to engineering. This will allow us to start an iteration process in which we can discuss, how we have implemented different mechanisms and whether they are still in line with the original psychoanalytic model. The outcome will be a refined implementation with improved abilities; we hope to continue this refinement process until we finally have overcome the oddities on the way to intelligent machines.

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