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CONSCIOUSNESS FOR THE OUROBOROS MODEL

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The Ouroboros Model features a biologically inspired cognitive architecture. At its core lies a self-referential recursive process with alternating phases of data acquisition and evaluation. Memory entries are organized in schemata. The activation at a time of part of a schema biases the whole structure and, in particular, missing features, thus triggering expectations. An iterative recursive monitor process termed "consumption analysis" is then checking how well such expectations fit with successive activations. Mismatches between anticipations based on previous experience and actual current data are highlighted and used for controlling the allocation of attention. In case no directly fitting filler for an open slot is found, activation spreads more widely and includes data relating to the actor, and Higher-Order Personality Activation, HOPA, ensues. It is briefly outlined how the Ouroboros Model produces many diverse characteristics and thus addresses established criteria for consciousness. Coarse-grained relationships to selected previous conceptualizations of consciousness and a sketch of how the Ouroboros Model could shed light on current research themes in artificial general intelligence and consciousness conclude this paper.

Keywords: Schemata; algorithm; cyclic; iterative; self-referential; consumption analysis; general intelligence; consciousness; higher-order personality activation.

1. Introduction

The Ouroboros Model describes an algorithmic architecture for cognitive agents. Its venture point are two simple observations: animals and human beings are embodied, strongly interacting with their living environment, and, they can only survive if they maintain a minimum of consistency in their behavior. As for bodily movement, also for cognition some measure of coherence and consistency is indispensable, e.g., nobody can move a limb up and down simultaneously, and, at least in real-world settings, opposites cannot both be fully true at the same time.

In a recent contribution a rather detailed description of the principal layout of the Ouroboros Model has been given together with a coarse sketch of how the proposed structures and processes can address various questions from half a century of research aiming for Artificial Intelligence [Thomsen, 2009].

The purpose of this contribution is not to deliver a treatise on specific intricacies of consciousness but rather to briefly investigate whether the proposed algorithmic

structure and processes could tell anything relevant relating to its observed characteristics and hitherto deducted criteria.

Before dwelling into some detail, a first look with a broad perspective should quickly check whether the account offered by the Ouroboros Model could fit at all with what had been demanded for explaining consciousness. Hypotheses, how the Ouroboros Model could possibly contribute to answering current questions about the link between consciousness and artificial general intelligence are meant as proposals for future research. For ease of reading, in the following presumed characteristics of the Ouroboros Model are described as if all conjectures had already been demonstrated convincingly.

2. The Ouroboros Model in a Nutshell

Understanding minds as primarily data processing entities, an iterative and self-referential universal algorithmic layout working in combination with suitable data structures has been proposed [Thomsen, 2008a].

2.1. *Action and memory structure*

The Ouroboros Model holds that memory entries are organized into hierarchies of schemata, i.e., meaningful junks of features and concepts belonging together. Neural assemblies are permanently linked together when once co-activated in the right manner. The activation of a feature promotes the selected concept and graded activation for each of the associated constituents, which are usually active in the same context. Activation at a time of part of a schema biases the whole structure with all relevant slots and, in particular, missing features.

2.2. *Principal algorithmic backbone*

At the core of the Ouroboros Model lies a self-referential recursive process with alternating phases of data acquisition and evaluation. A monitor process termed "consumption analysis" is checking how well expectations triggered at one point in time fit with successive activations; these principal stages are identified:

- …anticipation,
- action/perception,
- evaluation,
- anticipation,…

These sub-processes are linked into a full repeating circle, and the activity continues at its former end, like the alchemists' tail-devouring serpent called the Ouroboros.

2.3. *Consumption analysis*

Any occurring activation excites associated schemata. The one with the highest activation is selected first, and other, possibly also applicable, schemata are inhibited,

suppressed. Taking the first selected schema and ensuing anticipations active at that time as reference and basis, consumption analysis checks how successive activations fit into this activated frame structure, i.e., how well low-level input data are "consumed" by the chosen schema. Features are assigned/attributes are "explained away" [Yuille and Kersten, 2006].

If everything fits perfectly the process comes to a momentary partly standstill and continues with new input data. If discrepancies surface they have an even more immediate impact on the following elicited actions [Thomsen, 2008a]. In case of severe mismatch the first schema is discarded and another, new, conceptual frame is tried. The actual appropriateness of a schema can vary over a wide range. In any case, consumption analysis delivers a gradual measure for the goodness of fit between expectations and actual inputs, in sum, the acceptability of an interpretation. Thresholds for this signal are set in terms of approval levels depending on relevant experience in a context. There is a trade-off: in the real world nothing can always be perfect, but a wrong schema has to be abandoned at some point.

2.4. *Ways of concept formation*

Two types of occasions are directly marked in the Ouroboros Model as interesting by the outcome of the consumption analysis when attention is triggered leading to high excitement and strong activations; preferentially for these cases new records are laid down in memory [Thomsen, 2010]:

- Events, when everything fits perfectly; i.e., associated neural representations are stored as kind of snapshots of all concurrent activity, making them available for guidance in the future as they have proved useful once.
- Constellations, which led to an impasse, are worthwhile remembering, too; in this case for future avoidance.

These new memories stand for junks, later effective again as schemata, frames or scripts. Building blocks include whatever representations are active at the time when the "snapshot" is taken, including sensory signals, abstractions, previously laid down concepts and also prevalent emotions and longer lasting moods. They might in some cases but need not correspond to a direct representation unit like a word. At subsequent occasions they will serve for controlling behavior, by guiding action towards or away from the marked tracks, depending on the sign of the associated emotion signal.

Directly relevant to questions of self-consciousness, such snapshots of all related and strong activity in a brain will also contain and link features of the actor herself. These can span many levels of abstraction, including bodily status signals, motivations, as well as personal goals; somatic markers are one example, and higher-order thoughts follow suit [Damasio, 1996; Rosenthal, 1997]. "New" emotions are continuously computed with a measure of how well expectations based on old memories are met at any point in time. In addition, novel categories and concepts can be

assembled on the spot by combining existing memory entries. Over time some reorganization, statistical streamlining and grinding-in will lead to added abstractions [Thomsen, 2010].

Schemata, which include dimensions for actions and their resulting real-world consequences, deserve special mention as they have been claimed as fundamental for a sense of self-agency and for the design of self-conscious robots [Gallagher, 2000; Chella *et al.*, 2010]; also for the Ouroboros Model, they are a particular important type of schema.

3. Higher-Order Personality Activation

Any activity unfolds over time in discrete steps. Driven by a fundamental quest for survival and consistency, all available information ever laid down in the memory of an agent will be employed on demand. When selecting schemata and filling open slots we start with the most directly applicable entries and draw on more remote content, if nothing closer is found. The monitoring process does not only yield feedback on how well matters evolve but a measure for relevancy as well; it has been argued elsewhere that this signal including its grounding in a body can be equated with the feeling component of emotions [Thomsen, 2008b]. Activity is directed to the most urgent issues in a self-organized and flexible manner without any need for supervision. First, suitable schemata, missing parts and features are actively searched, and, if this does not produce satisfactory results, the whole interpretation or strategy, i.e., the current activated high-level schema, is abandoned. Interestingly, these process-basics hold true independently of the particulars of the employed schemata.

In any case, there are grades of automaticity, well established schemata and associations work as direct stimulus-response chains; we can follow their links absent-mindedly in an unattended "zombie" mode.

To the extent that directly fitting data are hard to detect or retrieve, activity spreads wider and more remote information is considered. The finally ensuing widespread activation unalterably involves various representations pertaining to the actor herself, the "narrative self".

This is Higher-Order Personality Activation (HOPA); it can be understood as a special version of a HOGS (Higher-Order Global State) version theory of consciousness as shall be explained below. Coarsely, the same arguments apply for HOPA as for HOGS with respect to the challenges issued against Higher-Order Thought (HOT) theories of consciousness [Rosenthal, 1997; Van Gulick, 2004]. Rather similar ideas have been argued for under the name of cross-order integration theory [Kriegel, 2007]. The above is a sketch of the short-term unfolding of activity kindling consciousness; additional processes come into play during long-term occupation with a specific question and general problem-solving.

Activity associated with consciousness according to the Ouroboros Model is not fully global — this would mean in the extreme that there is only one conscious state — but quasi-global. The idea here is that extensive activity involving areas

specifically representing the current content, as well as from areas coding different attributes of the agent himself is combined. This fits nicely with the observation that the apparently associated extended neural signature of self-consciousness appears to be very similar and includes medial and also (somatosensory association) parietal cortical areas, independently of the type and complexity of an actual problem setting [Newen and Vogeley, 2003; Davidson *et al.*, 2008].

For the implementation in human brains, there is wide consensus that coordinated activity comprising very different types of content corresponds to the concerted activation of widely dissociated brain areas, most probably demanding long range synchronization. "Unbinding", i.e., reducing effective connectivity in the cerebral cortex and thalomocortical systems by means of narcotics is a sure way to dim consciousness [Mashour, 2006].

In a truly multi-modal fashion, "global" activation comprising personal(ity) memories guarantees the unique and continuous character of a (conscious) self: the body and many other attributes of an agent usually change only slowly over time, their entirety thus establishes the recurrent theme for the development of a personality; widespread activation in a healthy subject does not leave out representations of any of his essential features. Similarly as for any schema, once established, the unity of consciousness does not require all features being fully present to evoke the gestalt later.

In the sense that self-referring and self-reflective associations are excited together with the content in the focus of attention, the ensuing total activation represents a higher-order (quasi-)global state. It can be conjectured that this is different for example in split-personality patients.

The Ouroboros Model can also be seen as a version of a global workspace theory. The well known global workspace accounts hold that it is of advantage to make information widely available in a brain, and then consciousness is claimed to ensue [Baars, 1988; Dehaene and Naccache, 2001].

In the framework of the Ouroboros Model most activation comes in shades of gray, all emerging in one fundamental algorithmic structure. Depending on the context and the current task, the filling of an open slot in a well established schema happens without any noticeable effort, or it might need serious devotion and the mobilization of all potentially useful (memory) capacities. Automatic reactions, as conceptualized by simple production rules mark one, the pre- or unconscious, end of the scale, full conscious concentrations of a dedicated person mark another.

Flow experiences, dreams or altered states of consciousness can then be understood as a consequence of reducing the ties to the outside reality while focusing on an activity with — in some way unusual — personal involvement [Echenhofer, 2008; Csíkszentmihályi, 1975].

4. What Would Count as Explaining Consciousness?

The Ouroboros Model claims that its basic algorithmic layout, the central data structures, i.e., schemata, and the associated processes, i.e., consumption analysis,

make up the functional "mental" core of natural actors — extending from simple reflex-like movements to the highest and most abstract levels of self-awareness and self-reflection. A simple observation in this respect is that the only agents with some (substantial) degree of general intelligence, that we know of, apparently can exhibit consciousness. According to the Ouroboros Model, the emergence of consciousness starts gradually, a main difference between species and also agents being founded in the schemata available to them.

The next step then is asking how the HOPA proposal fares in the light of established approaches and requirements related to the question of what can count as an explanation of consciousness, see Table 1 [Van Gulick, 1995].

Bullets A1−A6 contain explananda, i.e., features in need of explanation; bullets B1−B4 list explanans, i.e., the conceptual framework and the building material admitted in an explanation; bullets C1−C4 stand for various demanded relations between explananda and explanans. Like for many natural kinds and their attributes, some combinations are more likely than others.

According to the Ouroboros Model, mental states are conscious to the extent that they involve widespread and strong activations, including in particular representations of the agent himself. As much of the higher levels constituting a human personality are at least partly coded in action-, semantic and language terms, this entails some reportability corresponding to the ability of an agent (A1).

Baselining the same principal mental processes, varying levels of self-awareness and self-reflection and the availability of fine-grained abstract representations in different creatures correspond to their ability to experience and demonstrate consciousness (A2).

The Ouroboros Model emphasizes the importance of grounding. Actors are embodied, and this connects even the most abstract concepts to the outside reality.

Table 1. Main distinctions in R. Van Gulick's survey charting potential explanations of consciousness [Van Gulick, 1995].

Type	Title
A1	Distinction conscious/non-conscious mental states
A2	Distinction conscious/non-conscious creatures
A3	Qualia
A4	Phenomenal experience
A5	Subjectivity and Empathy
A6	Semantic transparency
B1	Physical/material
B2	Functional relations
B3	Naturalistic concepts
B4	Relations between non-conscious mental states
C1	Logic sufficiency/deductive entailment
C2	Nomic sufficiency
C3	Intuitive sufficiency
C4	Predictive and pragmatically useful models

Whoever has burnt his fingers knows perfectly well, that the concept of heat can have a very direct meaning to a living being. Qualia are (reportable) properties of objects that exist only from the internal perspective of an agent, a (conscious) self [Van Gulick, 1995]. Depending on personal histories, associations can vary: "red" might mean rather different things to an Inuit, to an Austrian blacksmith or to a philosopher. Qualia are seen by the Ouroboros Model as just one type of abstraction owned by an agent (A3).

The importance, ubiquity and unity of phenomenal experience is one of the key tenets of the Ouroboros Model; everything an actor experiences or does, and in particular all conscious action, is linked to the individual body, the mind, ratio and emotions, qualia and the legacy of the personal history of an individual in total (A4).

Intimately tied to the body of an agent, all her experience is private, owned by this particular subject; no one else can have the same direct access.

Nevertheless, the key ingredients to higher-level representations undoubtedly include attributes contributed by other agents. Social skills, e.g., shared and directed attention, have been claimed to be the distinguishing human feature [Tomasello, 2008]. Any healthy model of a developing self is strongly influenced by experiencing others in similar situations. Empathy as well as competition thus is part of the basis for consciousness (A5). Empathy could be seen as extending consistency and analogy outside that one agent, which is possible only above a minimum level of complexity. Other agents are similar and they experience, act, behave, and feel like the first actor. The way others behave towards an individual has a strong impact on what type and content of self-understanding this individual in a society and culture develops.

There is a very direct consequence of embodiment: all sensors, their signals as well as all derived representations simply make up the owner, the agent, and they are meaningful for him. Semantic transparency is a natural consequence of the iterative buildup in an agent, his individually-shaped conceptual structures laid down in personal memories (A6).

All of the reference frames listed under B1−B4 are claimed to be relevant in the Ouroboros Model. Humans are embodied; their brains are the substrate for the implementation of sophisticated data processing. The proposed algorithmic structure and, in particular, recursive consumption analysis lies at the heart of the decisive functional relations for all higher-level data processing. The Ouroboros Model delivers a natural account of how these structures could have evolved and how they develop in individual living creatures — starting at simple action → reaction chains and climbing up to comparisons between real performance and ought-to-be self-concepts. Any neuronally represented pattern can itself be incorporated into a larger structure, including inevitably ones reflecting on the agent himself.

The Ouroboros Model holds that HOPA (Higher-Order Personality Activation) ensues predominantly in situations when either consumption analysis signals very good performance and a significant accomplishment, or a very bad outcome: in both cases this leads to strong (quasi-global) activation exciting also representations

pertaining to the actor including her perceptions, beliefs and desires. When the focus is on the agent herself to start with, strong activation of references to that person's attributes follows trivially. The Ouroboros Model thus underwrites a specific version of a Higher-Order Global States (HOGS) account of consciousness, detailing its phenomenal structure, its physical basis, functional processes and relations — all in one common set of widely applicable naturalistic functional concepts. With more weight, e.g., importance, intention and attention, assigned to a specific topic, activation is stronger and chances for involving consciousness (exciting HOPA) are higher.

Section C of Table 1 lists main explanatory relationships, somehow ordered according to their stringency following the intuition or preference of the philosopher. Here, any ranking itself in the end has to be the result of evaluations in accordance with the direction of the genesis and abstraction outlined by the Ouroboros Model.

Of course, logical deduction, clear-cut dependency, together with the good feeling that everything appeals to the interrogator, are nice to have and should form the top goal, also in full accordance with the here suggested processes. Alas, what comes first and practically counts ultimately are usefulness and quantitative relations. Especially in the light of modern physics one has to accept that demanding "more than models" can be asking for too much. Quantum Mechanics delivers predictions of unbelievable accuracy, and yet, it appears to be beyond the direct grasping ability of almost all men. There is just too wide a gulf between our everyday world for which our senses and understanding capabilities evolved and the realms of the quantum world; and still, Quantum Mechanics' powerful predictions we are very happy with, and their usefulness is something nobody wants to give up.

When it comes to the very big picture, like an equation of state for the whole universe, the same limits apply and even more obstacles for a "complete understanding" come into focus. At some point, the only requirement that can meaningfully be put forward and that has a chance of some checking and allowing the possible refutation of a theory, is the one of all-encompassing (self-)consistency as no observer outside the universe can be asked for help in determining whether a description "really" applies (compare the consistent history approach in Quantum Mechanics [Omnès, 1999]).

Determining transparently and reproducibly the adequacy of a model in the end is feasible from the inside of an accessible frame or not at all.

In sum, the HOPA account of consciousness as offered by the Ouroboros Model shows some promise in addressing the requirements laid out by philosophy, similar as shown for the more standard HOGS theory while going much beyond it [Van Gulick, 1995; 2004]. The Ouroboros Model actually specifies *how* the whole could come about and it gives a clear conceptual description of the inner working of (conscious) minds.

Borrowing some words from Van Gulick, it can be safely hypothesized that the Ouroboros Model explains how the order and connectedness that we find within experience, its conceptual organization, its temporal structure, its emotive tones and

moods, and the fact that our experience is that of a (more or less) unified self set against an objective world are just facets, different results of the organization, the principle physical and algorithmic structure of an efficient mind in its interplay with other similar agents in the real world.

5. More Distinctive Features of Consciousness

Different active consciousness researchers have compiled slightly different lists of distinguishing features of consciousness, a representative one from a neuroscience venture point is given below in Table 2 [Seth *et al.*, 2006].

Addressing all the above issues in depth goes much beyond what is possible in this short note. Nevertheless, briefly listing immediate short responses from the point of view of the Ouroboros Model can give a hint to its usefulness and applicability. Detailed conjectures concerning the neural embodiment of the Ouroboros Model, its hypothesized implementation in human brain structures and processes, will be the subject of separate papers.

(1) As the Ouroboros Model has a cyclic procedure at its core, rhythmic brain activity has to be expected; variations in mental content lead to complex activations and irregular changes in measurable potentials [Tononi *et al.*, 1994; Seth *et al.*, 2006].
(2) Thalamic activations seem to be mandatory for widespread synchronized activity in a mammalian brain.

Table 2. Thirteen features of consciousness that require theoretical explanation according to Seth *et al.* [2006].

No.	Title
1	Consciousness is accompanied by irregular, low-amplitude, fast (12−70 Hz) electrical brain activity.
2	Consciousness is associated with activity within the thalamocortical complex (the "dynamic core"), which is modulated by activity in sub-cortical areas.
3	Consciousness involves distributed cortical activity related to conscious contents.
4	Conscious scenes are unitary.
5	Conscious scenes occur serially; only one conscious scene is experienced at a time.
6	Conscious scenes are metastable and reflect rapidly adaptive discriminations in perception and memory.
7	Conscious scenes comprise a wide multi-modal range of contents and involve multi-modal sensory binding.
8	Conscious scenes have a focus-fringe structure; focal conscious contents are modulated by attention.
9	Consciousness is subjective and private and is often attributed to an experiencing "self".
10	Conscious experience is reportable by humans, verbally and non-verbally.
11	Consciousness accompanies various forms of learning. Even implicit learning initially requires consciousness of stimuli from which regularities are unconsciously developed.
12	Conscious scenes have an allocentric character. They show intentionality, yet are shaped by egocentric frameworks.
13	Consciousness is a necessary aspect of decision-making and adaptive planning.

(3) As the representations of different types of content very likely are distributed widely over the surface of a cortex, widespread activation and binding necessarily entails distributed cortical (and associated sub-cortical) activity.
(4) In healthy subjects consistency is checked at a sufficiently high level, and in the end established globally. By definition, only one (quasi-)global and coordinated activity containing substantial contributions relating to one single agent is possible in one (healthy) brain at one point in time.
(5) The Ouroboros Model describes how phases of parallel activation and global checking of consistency advance in an overall serial process. Cortex activations with a very wide extent can only materialize one after another.
(6) Conscious states exhibit some inertia and persistence, a schema and the fit of relevant data have to be evaluated before a new concept is applied.
(7) Everything entering consciousness is represented neurally in its known human embodiment. Consciousness can encompass anything that can explicitly be represented by neurons and bound for HOPA.
(8) The Ouroboros Model proposes how consciousness normally goes hand-in-hand with attention; both are modulated and directed by the outcome of the consumption analysis. Focusing on one content with one schema excited, inhibits other, in particular, also neighboring schemata.
(9) The involvement of representations of the agent herself, as claimed to be of decisive importance by the Ouroboros Model, always relies on the same memory substrate of the person, her concepts and individual memory entries linked together in a peculiar way. Thus it is this one agent who owns her private consciousness.
(10) The wide ranging nature of conscious activations in a brain comprises all types of attributes, also semantic, linguistic and action-related features; thus, most often, conscious states and contents are reportable.
(11) The Ouroboros Model proposes how consciousness is related to learning; feedback from consumption analysis triggers both the establishment of novel memory entries and the spreading of activity often leading to an action or event becoming conscious.
(12) The Ouroboros Model is built around a basic drive for survival and following thereof, consistency for an individual; nevertheless, for developing her self-reflective consciousness over time input from other individuals is essential.

There is some discussion in the literature about the relation between consciousness and decision-making [Dijksterhuis *et al.*, 2006; Waroquier *et al.*, 2010]. The Ouroboros Model can explain that a type of effective inhibition of return follows naturally from the working of consumption analysis, which leads to the reported observations that ruminating after a decision is basically taken results in deteriorating performance.

(13) In the sense that planning, without doubt, deals with unfinished stories and thus schemata, for which slots are open by definition, planning is inevitably conscious.

5.1. *Still more to come*

In order to deal with the "highest" human characteristics, still more topics than the ones investigated so far will become relevant. Robert Van Gulick mentions Freedom and Creativity, J. R. Searle adds Society and Institutions, Politics, Ethics, Aesthetics, and Mathematics [Van Gulick, 1995; Searle, 2007]. Just to most briefly touch two of theses topics, the Ouroboros Model sees Mathematics as a particularly useful abstraction; some sketches relating to beauty have been presented before [Thomsen, 2000].

Further adding to the list of features to be explained, the author suggest that one should add sleep, which appears to follow natural intelligent behavior and also consciousness like a shadow [Thomsen, 2008b].

6. Instead of a Conclusion

With the restrictions mentioned at the outset, the Ouroboros Model is an ambitious attempt to approach an understanding of how and why a mind works and how consciousness ensues once a certain level of sophistication of self-awareness has been reached. It goes without saying that this short paper cannot be considered a compilation of well established results from in-depth research; rather, the presented propositions are considered plausible and intended as outlining a research program, directing future efforts to promising directions [Thomsen, 2009]. In the following, a few more theses, musings and predictions are sketched.

According to the Ouroboros Model consciousness in the form as we know it as human consciousness is very tightly linked to its embodiment, i.e., grounded in the body and its physical relations. Nevertheless, the organization of memory content into schemata and a thereupon resting consumption analysis process checking for consistency does not depend on exactly this type of embodiment. Thus, there seems to be no immediate or insurmountable obstacle to robots or software becoming truly intelligent and finally developing consciousness from the point of view of the Ouroboros Model. In particular, simple classical physics should do, no need for queer quantum effects is apparent, though they might one day be harnessed very advantageously for the required type of data processing [Thomsen, 2008c].

Humans obtain their conceptual structures in a lengthy learning process. For each person, details depend on the individual history and the world in which an individual thrives. Undoubtedly, the contents of machine as compared to human consciousness would be rather different. How embodiment, social or collective aspects of the generation of consciousness would impact machine consciousness are interesting questions.

Addressing the delicate question of why something like schematic memory chunks, consistency checking and self-reflection should evolve to start with, one can cautiously state that some organization and regularity in both the external world and its representation in a mind are required for making minds possible at all; any agent facing many severe inconsistencies in the relevant context of his world over extended

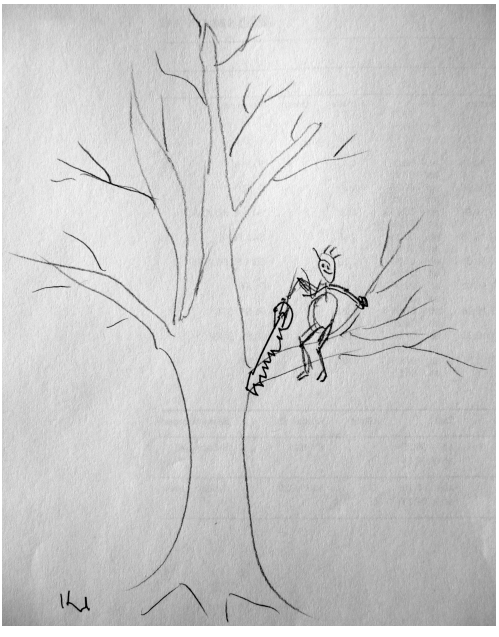

Fig. 1. A lack in self-awareness can easily become costly to an agent in the real world.

periods of time would not live very long. Some self-awareness in turn appears to be a mandatory prerequisite for a minimum level of intelligence; Fig. 1 illustrates that agents with inappropriate or too narrow schemata and lacking reflection upon themselves and their relation to the relevant environment can run into nasty problems. Extending self-awareness from simple bodily features of an agent to higher and abstracter levels is claimed as leading to full blown self-consciousness.

A first look at issues that any theory of consciousness should deal with shows that the HOPA proposal following from the Ouroboros Model appears to offer some promising aspects worth of further study.

As claimed before with respect to the applicability of the Ouroboros Model to topics in artificial general intelligence, the very fact, that in a self-consistent manner widely separated questions can be tackled within just one approach is taken as one of the main arguments in favor of the proposed structures and processes.

In the light of the Ouroboros Model, consciousness is a facet and rather direct consequence of the algorithmic overall set-up of efficient minds in the real-world context of survival.

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