Like cats and dogs: Radical constructivism and evolutionary epistemology

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Abstract

I identify two similarities between evolutionary epistemology (EE) and radical constructivism (RC): (1) They were founded primarily by biologists and (2) their respective claims can be related to Kant. Despite this fact there seems to be an abyss between them. I present an attempt to reconcile this gap and characterize EE as the approach that focuses on external behaviour, while RC emphasizes the perspective from within. The central concept of hypothetical realism is criticized as unnecessarily narrowing down the scope of EE. Finally, methodological and philosophical conclusions are drawn.

1. INTRODUCTION

In 1912, philosopher Bertrand Russell wrote: "*There is no logical impossibility in the supposition that the whole of life is a dream, in which we ourselves create all the objects that come before us. But although this is not logically impossible, there is no reason whatever to suppose that it is true*" (Russell, 1912: 35). Almost 90 years later, neurophysiologist Rudolfo Llinás seemed to contradict Russell's view. He argued that the mind is primarily a self-activating system, "*one whose organization is geared toward the generation of intrinsic images*" (Llinás, 2001: 57) and this makes us "*dreaming machines that construct virtual models*" (Llinás, 2001: 94).

In some sense these statements could be considered the respective epistemological mottos of evolutionary epistemology (EE)[1] and radical constructivism

[1] In the present context EE refers to evolutionary epistemology of mechanisms rather than evolutionary epistemology of theories—the classical distinction proposed by Michael Bradie (1986).

N. Gontier et al. (eds.), Evolutionary Epistemology, Language and Culture, 47–65.

(RC).[2] The former focuses on the *observation* of *external* entities, the latter concentrates on system-internal mechanisms (including an account for the activity of *observing*).

The paper starts with the observation that both disciplines are mainly supported by biologists and based on insights from ethology, biological morphology, neurophysiology and evolutionary theory. Despite the common roots (or because of them?) their mutual relationship seems to be dominated by animosities. I will outline the basic ideas that define (and separate) EE and RC in order to provide some answers to the question which of them is the 'correct' perspective. Steps towards a reconciling view have been taken by other authors, for example by Franz Wuketits (1992) and Sverre Sjölander (1997), whose respective interpretations of RC from an EE point of view seem to make the discrepancies disappear. However, there are reasons to assume that their understanding of RC is biased by their support for EE. Therefore, I will attempt a re-interpretation of one of the central notions of EE, *hypothetical realism*, from a RC perspective in order to assess their respective scientific value (and compatibility) for understanding cognitive systems.

Based on the analysis my conclusions will be twofold. From a methodological point of view, it appears possible to bridge the abyss between RC and EE. From a philosophical-linguistic perspective, however, they do not explain cognition equally well.

2. HOW TO APPROACH COGNITION

How can we account for cognition? As living beings we perceive a 'reality' full of different modalities and engage in a variety of actions. These impressions and experiences do not seem to come in chaotic disorder. Using our cognitive abilities, we make sense of the world. We can identify objects and distinguish them from one another. Also, we can manipulate entities in our reality, thus changing their configuration to meet our needs. All this seems rather self-evident and trivial to us. However, we did not possess this range of faculties at the time of our birth. Hence, there is an ongoing (and actually never-ending) process of cognitive development, which makes us what we are.

Similar observations apply to other *biological* entities, i.e., animals, as well. From their display of non-random behaviour we conclude—either as animal owner or professional ethologist—that they too do not just experience a chaotic disorder of colour and noise. Quite on the contrary, some reveal remarkable capabilities. However, there are differences. For example, it is hard

[2] Including Maturana's *Biology of Cognition* (e.g., Maturana, 1970; see also below) and Foerster's *Second Order Cybernetics* (e.g., Foerster, 1974).

to attribute human language capabilities to (most of) animals, and probably all fail to solve mathematical equations. Despite the gradual difference between humans and dogs, between cats and amoebas, one thing they all have in common is the ability to cope with their environment using their cognitive abilities. The complexity of ognition,[3] e.g., measured in terms of behavioural repertoire, is different for different individuals: There is a large-scale between zero cognition (non-living matter) and human-like cognition. If we trust in the idea of *biological* evolution (rather than creation) we have to ask for the mechanisms that evolved the wide range of different cognitive apparatus over time.

Both EE and RC set out to provide a naturalized account for cognition, and both refer to biology as the starting point of their consideration. Constructivist Heinz von Foerster (1984: 258), for example, prophesies that "*in the last quarter of [the 20th] century biologists will force a revision of the basic notions that govern science itself.*" Evolutionary epistemologist Wuketits claims that biological evolution can be extended far beyond its original scope: "*Since the human mind is a product of evolution—any opposite view such as that of classical dualism means a kind of 'obscurantism'—the evolutionary approach can be extended to the* products of mind*, that is to say to epistemic activities such as* science" (Wuketits, 1984: 8).

Therefore, EE and RC could be labelled competitive *research programmes* for studying the phenomenon of cognition. In a nutshell, the research programme of EE is intended to understand the evolution *of* cognition. It is based on a 'life is cognition' conception. Cognition is considered the result of exogenous factors such as evolution and environmental influences. In other words, EE is concerned about the *observation* of systems in order to derive insights about the observed systems.

While the constructivist programme, too, favours a 'life is cognition' approach, it differs significantly from EE by drawing attention to the process of *observing* rather than putting up with the *observed*. It contends that the real world consists of *what matters* instead of saying it consists of *matter*. Humberto Maturana (1978: 31) wrapped this starting point into his well-known statement "*Everything said is said by an observer.*" In other words, RC is the concept that individuals construct[4] their own realities whereby the observation

[3] It is important to note the difference between *cognition* and *intelligence*: Cognition is defined as the process of living, i.e., the interaction between an organism and its environment with relevance to the maintenance of itself. Intelligence, on the other hand, is considered as the capability of rational problem-solving (the domain in which artificial intelligence systems are supposed to excel).

[4] The term *construction* refers to the process by which complex structures are assembled from building blocks. RC assumes that there are generally applicable construction rules which are independent from the ontological nature of both the atomic components and the assembled

process cannot be separated from the observer. As a result, it emphasizes the internal perspective rather than the output point of view an observer is necessarily focussed on.

Let us have a closer look at both disciplines.

2.1. Evolutionary Epistemology

EE starts from the understanding that studying the evolution of the cognitive capacities of biological systems leads to an understanding of its functions, i.e., the cognitive processes that are responsible for the gain in knowledge an organism uses to survive in a dynamic world. Basic to its definition are early works such as Konrad Lorenz (1941/1982), Donald Campbell (1974), Gerhard Vollmer (1975/1987) and Rupert Riedl (1979/1984). It presents itself as a natural history or biology of cognition.

The evolutionists' approach is based on theories of evolution of behaviour in which cognitive processes play an important role. Such a *Darwinian epistemology* (Wuketits, 1991) starts from the paradigm of natural selection, which was traditionally been inseparably connected to the concept of adaptation. The emphasis on adaptation as an inevitable reaction process to a changing environment, including all structures and functions of the selective units, has been severely criticized for the conception that organisms passively react to their environments. This view goes back to Lorenz's 1941 publication where he wrote that the horse's hoof is a representation (*Abbild*)[5] of the steppe, the body form of the dolphin is the incarnation of knowledge about laws of hydrodynamics in water, etc.[6] Although the adaptive element of the evolution of cognition remains a key part of the evolutionary approach, its theoretical status has changed in the direction of a less restrictive interpretation. Eve-Marie Engels (1989) suggests refraining from adaptationism as the foundation for

complex structure, respectively. From a realist perspective cognitive representations are constructed out of objective facts, whereas constructivists maintain that representations are constructed out of simpler cognitive components.

[5] Space does not allow for a more detailed discussion of the (problematic) notion of representation. The classical *referential* theory of representation assumes a homomorphic mapping from structures of a mind-independent reality onto structures of the cognitive apparatus, i.e., subjectively experienced reality W is a function of the 'outer' reality R, $W = f(R)$. However, this naïve conception has been attacked by many authors (for details, see Riegler et al., 1999).

[6] "*Our categories and forms of perception, fixed prior to individual experience, are adapted to the external world for exactly the same reasons as the hoof of the horse is already adapted to the ground of the steppe before the horse is born and the fin of the fish is adapted to the water before the fish hatches"* (Lorenz, 1941/1982: 124–125). Lorenz (1973/1977: 23) states that *"an image of the material world is built up within the organism [. . .] a photographic negative of reality. . .* "

an evolutionary explanation of cognition. She argues in favour of a broader view on evolution within which organisms are interpreted as active systems, which do not just represent or reconstruct an external reality by applying their cognitive apparatus. So while adaptationism plays an important role in evolution, it is no longer considered to explain everything. Lorenz's example of the hoof depicting the hard steppe it runs on is valid as long as it is regarded a metaphor of the fact that the horse, by developing hoofs, has solved the problem of how to cope with the steppe (Oeser, 1987). Similarly, it does not make sense to claim that birds fly 'better' than bats or insects.

So why not extend the notion of cognition to cover more than just the *adaptive* side of behaviour? Several authors emphasized the tight relationship between life and cognition, and agree to this simple equation *Life = Cognition*, which puts the accent on the inseparable linkage between cognition and life. "*Living systems are cognitive systems, and living as a process is a process of cognition*", wrote Humberto Maturana and Francisco Varela (1980: 13). Adolf Heschl (1990: 18) claimed that both terms "*. . . are revealed as truly synonymous notions*". To view life itself as a knowledge-gaining process[7] is not only useful for metaphorical reasons, but has its merits in directing attention to the understanding of cognition as a bio-function which is necessary to guarantee, or even improve, the fitness of living systems. In other words, *the prototypical form of knowledge is knowing how to stay alive* (cf. Stewart, 1991, 1996).

2.2. Radical Constructivism

In contrast to the environmentally oriented view described in the previous section, the constructivist perspective emphasizes the autonomous role of the cognitive system. By proposing a non-adaptationist view, it suggests that the output of cognition is mainly a function of the cognitive system itself, especially of its self-organizing and constructive activities. Here, the active role of the organism is stressed, and the direction of causation has been reversed in favour of a subject-centred perspective: the organism itself influences its environment.

Putting the stress on being the discipline that sees things *from within*, RC expresses the insight that experiences are all we have to work with, that out of experiences we construct what appears to us as 'world', and that "*we cannot transcend the horizon of our experiences*" (Riegler, 2001b: 1). A way to understand the constructive elements included in cognitive phenomena is illuminated by *cognitive constructivism*, a programme that is strongly intertwined

[7] Cf. also Lorenz's well known dictum *"Life itself is a process of acquiring knowledge."*

with the work of Jean Piaget's *genetic epistemology* (e.g., Piaget, 1937/1954). This psycho-ontogenetic position contributes to the synthesis of self-organizing and adapting elements in the course of the individual's cognitive life by introducing the concepts of assimilation and accommodation as functional conditions for the cognitive process. It stresses the importance of the cognitive development of human beings, i.e., the ontogenetic evolution. Cognition must not be seen as static ability but rather as a dynamic process that has its origin in the sensorimotor stage of early childhood. Following Piaget's insights, Ernst von Glasersfeld (1991) claims that knowledge is not passively received but actively built up by the cognizing subject. Furthermore the function of cognition is adaptive; it serves the organization of the experiential world, not the discovery of ontological reality.

Maturana and Varela (1980) have developed their constructivist theory by taking for granted that living systems are cognitive systems defined by their *self-referring* organization. Being organizationally closed these systems are autonomous.[8] In other words, RC draws attention to the point that cognition in general and knowledge about the 'world' in particular must not be viewed as a mapping of features of an external world but rather as the ability to act appropriately in the environment.

3. COMPARING EE AND RC

As we have seen above, both disciplines set out to provide a naturalized account of cognition, and both refer to biology as the starting point of their consideration. Further similarities can also be detected among their respective proponents as well as their philosophical heritage.

3.1. The Proponents

In 1957, Foerster founded an interdisciplinary laboratory at the University of Illinois. Inspired by the emerging discipline of cybernetics in the late 1940s and early 1950s he called it the *Biological Computing Lab* (Müller, 2000). As the subtitle of their annual transactions (Pias, 2003) announced, cyberneticians focussed on circular-causal and feedback mechanisms *in* biological and social systems. Another proponent of RC, Maturana, made a career in neurophysiology where he first investigated the eye–brain connection *in* frogs (Lettvin et al., 1959). Later his attempts failed to investigate whether the *spectral composition*

[8] For an application of closure to cultural contexts, see Liane Gabora (2000).

of colours correlates with the activities in the retina of pigeons. What he found instead was that the activity of the retina can be connected to the *names* of colours, which are considered to be rough indicators of how colours are *subjectively* experienced (Maturanaet al., 1968). Maturana's astonishing conclusions were that the objective of his research had turned to comparing "*the activity of the nervous system with the activity of the nervous system"* rather than with an external reality (quoted in Pörksen, 2004: 61). The theoretical framework he developed from his experimental research is called *Biology of Cognition* (Maturana, 1970). Finally, Gerhard Roth's constructivism (e.g., Roth, 1994) arrives from the perspective of 'cognitive neurobiology'. Starting from neurophysiological insights, his goal was to formulate rules for the construction of reality *in* the brain.

In the EE camp, Lorenz was a famous ethnologist, whose groundbreaking studies of the *behaviour* of geese made him world-famous (e.g., Lorenz and Tinbergen, 1939). In 1973, he won the Nobel Prize for his studies of human and animal behaviour. In particular, Lorenz investigated imprinting and instinct behaviour of animals, the release mechanism that responds to key stimuli, fixed action patterns which serve as the foundation of the study of animal behaviour, as well as the phylogenetic development of innate behaviour.The starting point for his student, marine biologist Riedl was morphology, which deals with the *forms* and *shapes* of organisms or parts thereof. Soon he turned to his second passion, the biological-philosophical roots of knowledge, in particular to the study of homologies, which explains the structural similarity between different species in terms of shared ancestry. His 1979 book carries the name *Biology of Knowledge*, in which he argues in favour of evolution as a knowledge-acquiring process propelled by adaptation through which the laws of nature can be extracted. It is interesting to note the apparent similarity between Maturana's and Riedl's book. The former, however, refers to the dynamical process of cognition, the latter to the static quality of knowledge.

The observations presented in this section suggest that RC proponents have developed a preference for looking at the mechanisms *inside* systems, i.e., they are interested in the *inner* perspective. In contrast, supporters of EE emphasize observing behavioural patterns, i.e., they are interested in the *outside* view. They observe behaviour and postulate a link between their rule-like behaviour and general laws of cognition and (phylogenetic) knowledge acquisition. Whether being ethologists or morphologists, the focus of attention is the *output* of the observed system, which they map onto their own experiential network. Behaviours are anthropomorphically *attributed* (Sjölander,

1997).[10] However, an observer is not necessarily embodied in the world of the observed animal (Nagel, 1974; Riegler, 2002). Rather she interprets its behaviour within her own referential system of understanding. This reminds us to Richard Feynman's (1985) cargo cult science criticism, an analogy where islanders tried to replicate the *shape* of Western technology (an airport) with wooden models simply because primitive mechanical models were *their* referential system, the only one they had access to. Consequently, the inner working of a genuine airport completely escaped their intellectual capacities. For EE this means that even if we had the intellectual capacity to make inferences from the appearance to the inner working, we would face a huge number of possible mappings from observational data onto the model. There is a sheer astronomical number of ways to explain data points (McAllister, 2003). Facing this intellectual problem, all we can do is *trivialize* complex systems (Foerster, 1972). That is, we reduce the degrees of freedom of a given complex entity to behave like a trivial machine, i.e., an automaton that maps input directly on output without recurring to internal states.

Ultimately, the gap between EE and RC can be considered a typical instantiation of what Valentin Braitenberg (1984) called the *law of uphill analysis and downhill synthesis* with EE trying to analyze (the complexity of) observed systems and RC synthesizing their complex psychological behaviour in terms of simple rules at a low level. Even though 'non-armchair' radical constructivists such as Maturana and Roth started as *observing* biologists (like many others in the EE camp), they later turned their attention to the individual's *input* perspective. As mentioned above, in Maturana's concept of autopoiesis[11] the crucial aspect is that of self-reference: Not the output defines autopoietic (i.e., living) systems. Rather they perform a certain output in order to control their input state such as state of hunger, and other crucial parameters (cf. also Porr and Wörgötter, 2005). Therefore, modelling living systems—as a procedure to trivialize complex systems in the above sense—must be considered as turning autopoietic machines into allopoietic ones, i.e., as opening their fundamental closure with respect to the modeller. Maturana notes that

[10] Cf. also Foerster (1970, 2003: 169) who characterized "*anthropomorphizations*" as "*projecting the image of ourselves into things or functions of things in the outside world* ".

[11] According to Maturana (1970, 1974, 1978, 1988; Maturana and Varela, 1980), autopoietic systems are a subset of self-organizing systems that obey the following criteria: (1) The components of autopoietic systems take part in the recursive production of the network of production of components that produced those components. (2) An entity exists in the space within which the components exist by determining the topology of the network of processes. A system that does not fulfil these criteria is called allopoietic, e.g., machines that serve a different purpose than maintaining their own organization.

> [. . .] an observer may treat an autopoietic system as if it were an allopoietic one by considering the perturbing agent as input and the changes that the organism undergoes while maintaining its autopoiesis as output. This treatment, however, disregards the organization that defines the organism as a unity by putting it in a context in which a part of it can be defined as an allopoietic subsystem by specifying in it input and output relations. (Maturana, 1974: 468)

We have to conclude that observed behaviour, i.e., a protocol of inputs and outputs, cannot capture the essence of a living organism.

3.2. The Heritage of Immanuel Kant?

It is interesting that both EE and RC can also be traced back to Immanuel Kant. Lorenz (1941/1982) naturalized Immanuel Kant's (1781) a priori of space and time, which Kant regarded indispensable for understanding raw sensory experience, and re-interpreted them as phylogenetically acquired categories. According to Lorenz, EE is the world of the paramecium and "*barbarian seal hunters*" (see below). The evolutionarily acquired *Denk- und Anschauungsformen* do not distort our view on reality in itself but rather deliver a true albeit simplified picture.

> We have developed 'organs' only for those aspects of reality of which, in the interest of survival, it was imperative for our species to take account, so that selection pressure produced this particular cognitive apparatus . . . [W]e must assume that reality [*das An-sich-Bestehende*] also has many other aspects which are not vital for us, barbaric seal hunters that we are, to know, and for which we have no 'organ', because we have not been compelled in the course of our evolution to develop means of adapting to them. (Lorenz, 1973/1977: 7)

He called these inborn structures *innate teaching mechanisms* [*Angeborene Lehrmeister*]: "*These mechanisms also meet the Kantian definition of a priori: they were there before all learning, and must be there in order for learning to be possible"* (Lorenz, 1973, 1977: 89). Following Egon Brunswick (1955), Riedl (1979) speaks of the *ratiomorphic apparatus*. That is, human beings feature a system of *innate* forms of ideations that allows the anticipation of space, time, comparability, causality, finality, and a form of subjective probability or propensity (Riedl et al., 1992). In this sense, from the perspective of EE biological insights support the Kantian a priori of individual cognition.

For RC, Kant's *Copernican Turn* can be identified as a motivational stepping-stone. Kant (1781: Bxvi) argued that so far "*it has been assumed that*

all our knowledge must conform to objects"—an approach that he regarded a failure. Instead he proposed a 'Copernican Turn', according to which "*objects must conform to our knowledge*" (ibid.) (rather than the other way around), thus radically dismissing any form of determinism of the cognizing individual through the outside reality (see also Bettoni, 1997). In order to implement the Copernican Turn we refer to what Foerster called the *principle of undifferentiated encoding*. It was first formulated in the late 19th century and applies ubiquitously in the nervous system: *"The response of a nerve cell does not encode the physical nature of the agents that caused its response. Encoded is only 'how much' at this point on my body, but not 'what'"* (Foerster, 1973: 214–215). Maturana and Varela enlarged this argument to what they call the *organizational closure* of the nervous system, which is *"a closed network of interacting neurons such that any change in the state of relative activity of a collection of neurons leads to a change in the state of relative activity of other or the same collection of neurons*" (Winograd and Flores, 1986: 42). Therefore, the cognitive apparatus necessarily constructs its reality and the entities it is populated with in the first place. Perturbations from the outside may, at best, modulate the dynamical construction process of the cognitive apparatus but not determine it. There is no purpose attached to this dynamics, no goals imposed from the outside relative to the cognitive apparatus. In other words, the cognitive apparatus predetermines what to perceive thus implementing Kant's Copernican Turn: Objects conform to the cognitive apparatus. Its dynamics follows the *constructivist-anticipatory principle* (Riegler, 1994): The mind constructs cognitive structures in the first place and seeks occasionally to validate them through sensory input. Riegler (2001a) compares this with a relay race where the runners focus on their running except for the short moments of coordination when they pass the baton on to the next runner. One could describe the moments of coordination as *checkpoints* (Riegler, 1994) where the runner verifies that he is still on track such that the race can go on with the subsequent team member. Oliver Sacks's (1995) example of a blind man demonstrates that humans rely on such relay race-like cognitive strategies. The man recognized things by feeling their surface in a particular order. When walking through a familiar place he did not get lost because he relied on a certain sequence of tactile impressions he would encounter. This applies to visual perception as well. For Kevin O'Regan and Alva Noë (2001) *seeing is knowing sensorimotor dependencies*, and the brain is a device to extract algebraic structures between perception and action (rather than from the world). All these constructivist concepts support the Kantian idea of the mind commanding reality.

3.3. The Controversy

Sadly though, despite their identical starting points and goals EE and RC do not go well together. Glasersfeld (1985), for example, points out that one

of EE's central notion, adaptation, even in the weaker sense as described above, is meaningless. For him, Popper's (1963) rejection of instrumentalism (a cornerstone of RC) on the basis of its inability *to account for the pure scientist's interest in truth and falsity* is unacceptable polemics. Riedl, on the other hand, is eager to dismiss RC as a solipsistic school. In his favourite thought experiment the sudden appearance of a rhino at a congress of constructivists teaches them that reality does exist. His aversion to the constructivist worldview springs from Lorenz' motto "*To believe plain nonsense is a privilege of the human being*" (quoted in Riedl, 1979: 34). It expresses the conviction that organisms that do not 'believe' in a mind-independent reality will be eradicated by natural selection (see also Wuketits, 1992). The problem of nonsense constructions will be addressed in the following section.

One of the major obstacles to overcome the (often polemic) controversies between EE and RC is the former's clinging to *hypothetical realism*. Although proponents of EE admit that "*realism involves presumptions going beyond the data*" (Campbell, 1974: 449), they cannot help but claim that it not only exists but that it can also be known: "*[W]hat an organism construct must, one way or another, correspond to some aspects of reality* . . . " (Wuketits, 1992: 158).

4. HYPOTHETICAL REALISM FROM A RADICAL CONSTRUCTIVIST PERSPECTIVE

For Vollmer (1987), Russell's 1912 quote (as mention at the beginning of the introduction) was a motivation to compile a list of 13 arguments in support of EE's reality postulate. The first of these arguments he called the *psychological evidence.* It is this evidence that continuously convinces us of the factual existence of a mind-independent reality based on our commonsense reasoning. He refers to Russell's notion of *instinctive belief.* It is caused by experiences of resistance or pain, but also by the fact that other people talk about things out there with the same matter of course as we do—or at least as Vollmer does.

Let us have a closer look at this 'experience of resistance'. One does not need to recur to Riedl's colourful rhino thought experiment, simple questions of the sort "Does this table her in front of me exist?" or "Surely, you still believe that when the door is closed you cannot walk through it don't you?" seem to be powerful enough to refute RC. What, for example, prevents the reader from constructing the fact of reading this article in this very moment and flying over the Grand Canyon an instant later? Obviously there *must be* limits to how the cognitive apparatus constructs reality otherwise RC would render irrelevant. It is of crucial importance to not let an adverb sneak in: Constructing our own

world must not be equated with *arbitrarily* constructing our own world. So how to keep the adverb out?

Experiences are made subsequently. As such, they are connected with each other in a historical manner and form a network of hierarchical interdependencies (Riegler, 2001b). The components of such a network are, therefore, mutually dependent; removing one component may change the context of another component. In this sense they impose constraints on each other, very much like the constraints-analogy provided above. By car, you can reach only those points which are connected to the road network, by foot, all the points in between can be accessed as long as they are within walking distance. Each means of transportation restricts the availability of reachable destinations. Free arbitrariness is not possible since different means of transportation have different degrees of flexibility and speed. Similarly, the construction network of the mind is also necessarily non-arbitrary. It follows the canalizations that result from the mutual interdependencies among constructive components. Once a certain path is taken with regard to relating components to each other in a particular manner, the mind uses previous constructions as building blocks for further constructions.

Likewise, the 'reality' of a door and the experience of bumping into it are mental constructs that are mutually dependent. On a meta-level, we can reflect on the components of the compound constructions and do as if we could deal with each component separately, or change the features of isolated entities as if those features would not depend on other elements.

Sometimes, however, there are cases in which we can deliberately change the mutual relationship among constructions to different degrees. Boicho Kokinov (1997: 3) hints at this fact by discussing various steps of accessibility.

> At the lowest end a memory trace could be completely inaccessible (neither consciously, nor unconsciously) at a particular moment, then it could be only unconsciously (implicitly) available (demonstrated by priming effects, but failing to be recognised in an explicit memory task, for example), then it could be consciously available (demonstrated by a standard recall or recognition task), and finally the very fact of existence of the memory trace might be consciously available (demonstrated in a meta-cognitive 'feeling of knowing' experiment).

So certain classes of constructions seem reversible to some degree. Mathematical problems, for example, can get suddenly solved after a mind-relaxing night. Problems regarding the construction of social relationships may already take longer. They sometimes need therapy, e.g., Paul Watzlawick's family therapy (Watzlawick et al., 1974), which tries to reframe a habitual situation to make participants recognize solutions.

Only for constructs with an even longer history and/or bigger number of mutually dependent components we can expect even more insuperable obstacles in somebody's attempt to change them, such as our idea of doors and bumping into them. An indication that parts of our memory are no longer accessible by conscious (and verbal) thought is provided by the results of Gabrielle Simcock and Harlene Hayne (2002) on the puzzle of childhood amnesia, i.e., the phenomenon that we forget about our earliest childhood experiences up to the age of 3. The authors were researching very early verbal memories and found that children can only describe events from early childhood using the limited language they knew at the time. Their ability to remember exceeded their ability to talk about the experimental device that magically shrinks toys—an event spectacular enough to be remembered. One year after their first contact with the machine, the children still displayed the non-verbal procedural knowledge to shrink a toy. However, when trying to recall their memories they were unable to use newly acquired words that were by now part of their everyday vocabulary. Their verbal descriptions of the event were "*frozen in time, reflecting their verbal skill at the time of encoding, rather than at the time of the test*" (Simcock and Hayne, 2002: 229). Therefore, cognitive development seems to resemble a ratchet (see Riegler, 2001a) in that once the individual starts to reason in language it cannot reach back to unconscious procedural memories.[12]

What are the implications for the argument against hypothetical realism? If humans cannot translate their preverbal memories into language, how can basic sensorimotor constructs made in that early period be reasoned about and claimed to be part of a mind-independent reality? As Siegfried Schmidt (quoted in Pörksen, 2004: 134) put it, "*For if I want to know whether this table exists, there already has to be a table in my experiential reality I can deal with. The question of whether this table exists or not is an assertion that neither adds to, nor subtracts from, existence.*" That we can isolate the concept of table from its defining (dynamical-operational) context—to abstract from its embeddedness (Riegler, 2002)—is a remarkable feat of language only, yet it does not make sense on the level of experiences (Riegler, 2005).

The conclusion from this section is straightforward. The argument that we *have to* assume a mind-independent reality in order to account for cognition—based on the claim that purported real things resist our actions and thoughts—is rejected. It rests on the incorrect premises that linguistic-philosophical reasoning (let alone common-sense 'talking about') could reach down to very early (sensorimotor) experiences and assess them appropriately.

[12] This indicates also that constructions are not necessarily linguistic by nature.

5. CONCLUSION

So which perspective is the 'correct' one? If following the arguments in the previous section we have to drop the idea of hypothetical realism; speaking of adaptation as the source of cognitive knowledge acquisition does not make sense. The EE literature often quotes Simpson (1963) argument "*The monkey that had no realistic perception of the branch he was jumping for was soon a dead monkey—and did not belong to our ancestors*"(Sjölander 1997:596) as an illustration of how important the a priori ontology of a mind-independent reality is. Vollmer (1987: 36) quotes Max Planck according to whom the scientist has to assume the existence ("*als vorhanden annehmen*") of the appearances and laws which she is searching for. Vollmer, of course, meant to refer to *real* things, to *real* branches, etc. However, from a cognitive point of view the existence of branches is uninteresting. Rather, what ought to be the focus of interest are questions such as "How did the monkey learn to grasp in the right moment?" Consequently, Planck's statement is to be interpreted in a quite different sense. (1) As cognitive scientists we do not search for real branches—that is left to botanists. Rather we want to learn about cognitive mechanisms. (2) The German expression 'vor*hand*en sein' used by Planck relates to the aspect of *manipulation* (Latin 'manus' = hand) rather than to *ontological* statements. Knowledge, therefore, is knowledge about change and transformation rather than about static things and relationships (operative rather than figurative knowledge in the sense of Jean Piaget; cf. also Kevin O'Regan and Alva Noë, 2001). On which assumptions does such knowledge rest?

It seems that we have to agree with the conclusions of Engels (1999). Traditional problems of philosophy cannot be solved by biology. Out of necessity biology has always to start with the assumption of a reality populated by animals. Since biology always makes existential claims in the first place every attempt to prove the existence of an external mind-independent reality including the existence of other subjects renders necessarily circular. In mathematical-formal systems, where the truth of a proposition is proven by establishing a link of deductive sets between the set of axioms and the proposition in question, you cannot prove the validity of the axioms within the system either. For the validity of propositions within a formal system it is entirely irrelevant whether its axioms are true within a broader encompassing system.

Furthermore, does not restricting itself to experience rather than letting a mind-independent reality be the (easy) arbiter of hypotheses and theories severely limit the range of applications of RC? I maintain that, quite on the contrary, RC has a *broader* scope than EE. By putting the emphasis on *observing* systems rather than on *observed* systems (Foerster, 1984), RC not only includes observed systems but also attempts to account for observing.

Consequently, it demands from science to develop a *theory of the observer*: "*Since it is only living organisms which would qualify as being observers, it appears that this task falls to the biologist. But he himself is a living being, which means that in his theory he has not only to account for himself, but also for his writing this theory*" (Foerster, 1984: 258). While EE is at the mercy of its own a priori settings regarding the threat of self-contradiction and circularity (as it tries to explain its own axioms, i.e., the biological a priori of cognition), the biological roots of RC are but a basin of its argumentative attractor. For example, the principle of undifferentiated encoding of nervous signals resulting in cognitive closure does not rest on the assumption of a (hypothetical) realism: Whether *or not* we assume the reality of undifferentiated encoding in the nervous system we cannot escape the fact that it is organizationally closed. Hence it is impossible to speak about reality. It is a Wittgenstein ladder leading to the insight that the purported mind-independence of reality cannot be considered an axiom. As Glasersfeld (1995) pointed out we cannot verify our belief in a mind-independent reality if all the means we have to validate it are the senses through which we gathered the sensor data on which the belief rests. This situation compares to being prosecutor and judge at the same time: It renders independent validation impossible. Therefore, we not only have to put up with experiences as the sole point of reference; we also have to re-consider the nature of 'reality'as useful everyday construction at best. In other words, RC does not ask the question of EE: "What are the Kantian a priori?" Instead, constructivists stress the fact that we can never know anything about the thing in itself, *das Ding an sich* (Sjölander, 1993; Riegler, 2001b).

The arguments brought forth in this paper suggest two solutions for the RC versus EE dilemma. First, from a modelling perspective a collaboration between EE and RC appears possible. *Ontogenetic* aspects of cognition can be modelled by applying ideas of constructivism, which underlines the organizational closure of cognitive systems. This means that the cognitive apparatus deals exclusively with its own states. Only through a transduction shell, which works *independently* of the cognitive apparatus, sensor inputs to internal are mapped onto states, and which are mapped back to outputs. *Phylogenetic* aspects are modelled along evolutionary theories and follow insights from EE. This means that a population of organizationally closed agents starts with phylogenetically inherited cognitive structures representing innate *anschauungsformen* (Riegler, 1994). This implements Lorenz's *lehrmeister*.

On a philosophical level, however, the mutual rejection in spite of common grounds could also be interpreted as a paradigmatic example of Josef Mitterer's (2001) treatise on dualistic ways of (scientific and philosophical) knowledge acquisition. Dualistic approaches, being the prevailing scientific orientation, are based on the distinction between description and object, and their argumentation is directed towards the object of thought. Mitterer's thesis

says: The dualistic method of searching for truth is but an argumentative technique that can turn any arbitrary opinion either true or false. Epistemological paradigms become visible in hindsight: Another university, other teachers and an evolutionary epistemologist would have become a radical constructivist, and the other way around. For example, Lorenz's statement (quoted after Sjölander, 1997: 595), "*we only perceive the world indirectly, i.e., what I see, hear, touch or smell is a world created—constructed—within my brain, it is by no means a picture of the world as it actually is*" could have been written by a radical constructivist as well.

In conclusion, the main difference between EE and RC is the respective setting. For EE living systems are defined over their output. The basic assumption of EE is a world populated with entities, i.e., a world that consists of matter. The RC perspective, however, suggests that for living organisms the output is just a means to control their input. They act in order to keep input states in equilibrium. Therefore, for a living being the world consist of what matters. This does not mean that according to RC "the world is exclusively in the mind/head" because this reproach assumes a world that consists of matter, including heads. Despite forgoing this assumption in RC, there is no arbitrariness of world construction. It is prevented by mutual dependencies among construction elements rather than through an alleged external reality. Furthermore, RC interprets the basic assumption of EE as part of the organism's strategy to keep its input stable. In order to regulate the input through its outputs the organism introduces a causal chain carried by hypothetical entities in its environment through which its input is ultimately affected. EE remains on the level of the description of this causal chain and considers it *the* reality whereas RC regards it *a* reality. Therefore, the EE perspective is a subset of RC.

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