Introduction

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The aim of this book is to present the paradigm of enaction as a framework for a far-reaching renewal of cognitive science as a whole.[1] There have been many critiques of classical, first-generation cognitivism based on the Computational Theory of Mind. A distinctive feature of this book is a deliberate choice not to go over that old ground yet again, but to reserve the energy for positive exploration of new paths.

Enaction, initially articulated as a program for understanding cognition by Varela, Thompson, and Rosch (1991), has seen an explosion of activity in recent years, including a follow-up book investigating the deeper connections between life and mind (Thompson 2007), related special journal issues (Barandiaran and Ruiz-Mirazo 2008; Di Paolo 2009; Rohde and Ikegami 2009; Torrance 2005, 2007), many articles reporting on theoretical and empirical advances and several regular meetings, summer schools, and funded projects. This program makes a radical break with the formalisms of information-processing and symbolic representations prevalent in cognitive science. In their stead, as explained in the first text, by John Stewart, cognition is grounded in the sensorimotor dynamics of the interactions between a living organism and its environment. In the classical scheme, perception is relegated to a preliminary "module" based on sensory input alone, to be followed in a linear sequence by "cognitive" planning and representations of goals, and culminating in a decision to act. In this scheme, "cognition" is thus sandwiched between two layers—sensory input and motor output—which are not themselves considered as properly cognitive. The perspective of enaction overturns this scheme quite radically. A living organism *enacts* the world it lives in; its effective, embodied action in the world actually constitutes its perception and thereby grounds its cognition. The text by Renaud Barbaras takes as its springboard the observation that "to live" *is* to have intentional conscious experience of living, and engages a profound

phenomenological analysis of the implications, including the relation between life and metabolism.

In fact, there is a growing realization and acceptance in cognitive science that perception is not just a subsidiary module, and that embodied action is at the root of cognition as a whole. Nevertheless, there lingers a persistent impression in the community that this may be all very well for "low-level" cognition, but that when it comes to "high-level" cognition—thought, reasoning, planning, problem-solving (which after all is what "real cognition" is about)—then computational cognitivism remains the only viable option. A major aim of this book is to show that this impression is quite false, and to substantiate the claim, not just in abstract principle but in terms of actual research, that the paradigm of enaction has its own and highly distinctive approach to higher-level cognition. Thus, the themes of consciousness (Benny Shanon), socially shared abstract concepts (Ed Hutchins), mathematics (Rafael Nuñez), language (Didier Bottineau), the human brain (Andreas Engel)—particularly its relation to lived experience (Michel Le Van Quyen), and emotion (Giovanna Colombetti)—all form important chapters in the book.

Indeed, if there is a problem, it is not so much *engaging* with "high-level" cognition, which, as we have seen, the paradigm of enaction does in richly varied ways; it may be, rather, in ensuring an adequate *articulation* between "low-level" embodiment and high-level human cognition. A significant and relatively original contribution of this book is that it does not seek to evade this issue, but addresses it quite squarely. Thus, the opening chapter by Stewart proposes a methodological principle—that of studying cognitive phenomena by way of their historical *genesis* through phylogeny and ontogeny—which aims precisely at overcoming any such hiatus. Chapter 2, by Ezequiel Di Paolo, Marieke Rohde, and Hanne De Jaegher specifically seeks to characterize enaction as a paradigm, with its core ideas and its horizons. They provide enactive accounts of value-generation and social interaction, which they compare favorably to computational approaches. They adopt a bottom-up approach, including but not restricted to evolutionary robotics as a method for grounding complex ideas in simple models. And, exploring an enactive route to higher level forms of cognition, they show how *play*, an activity that allows the development of meaning-manipulation skills as well as a further level of autonomous cognitive self characteristic of human beings, can emerge as a value-generating process from the basis of embodied sense-making.

More generally, we invite our readers to pay particular attention to the ways in which, *within* each chapter, the question of the relations between

different levels of organization are addressed. Chapter 3, by Renaud Barbaras, does this in the most striking manner, by positing straight off that the lowest level of all—the basic processes of metabolism and movement—should be studied in such a way that it can be understood as containing already the germ of the highest level of all: reflexive consciousness as investigated by phenomenology. The next four chapters, devoted to questions of embodiment, each do so in a way that highlights developmental aspects. Chapter 4, by Adam Sheya and Linda B. Smith, is explicitly developmental, and suggests that Piaget's notion of a certain pattern of activity—an accidental action that leads to an interesting and arousing outcome and thus more activity and the re-experience of the outcome—sets up an autonomous dynamic that may be foundational to development itself. Giovanna Colombetti (chapter 5) considers that much of current emotion research suffers a form of "Cartesian anxiety," stemming from the false assumption that cognitive evaluations are necessary to trigger behavioral responses appropriate to the situation. She proposes an "enactivist therapy" in order to recover the intimate unity of mind and body that Descartes himself recognized as being the core of emotions. Maxine Sheets-Johnstone (chapter 6) evokes research studies of infant understandings of *in*, *insideness*, and so on, which are highly revealing for what they say and do not say about kinesthesia and thinking in movement. Careful reflection on these studies from an experiential perspective shows that we put the world together in a spatial sense through movement and do so from the very beginning of our lives. Spatial concepts are born in kinesthesia and in our correlative capacity to think in movement. Accordingly, the constitution of space begins not with adult thoughts about space but in infant experience. Finally, in this group of chapters, Olivier Gapenne (chapter 7) considers that the constitution of a "kinesthetic function," itself rooted in proprioception, is foundational for the emergence of the prereflective experience of spatiality and distal objects. His main point is to suggest that the distally perceived (tangibility and form) object is nothing else than the experience of body motion. In line with this, the spatial extension of the perceived object results from a multiscale bodily deployment constrained through a multisensory flow which defines an enactive dynamics.

With the next two chapters, we turn from embodiment to the nervous system and the brain. This is, however, anything but a break. Andreas K. Engel (chapter 8) recalls that in current cognitive science there is a "pragmatic turn" away from the traditional representation-centered framework toward a paradigm based on the notions of "situatedness" and "embodiment" that focuses on understanding the relevance of cognition for action,

and the real-world interactions of the brain. Such an "action-oriented" paradigm has earliest and most explicitly been developed in robotics, and has only recently begun to have an increasing impact on cognitive psychology and neurobiology. The basic concept is that cognition should not be understood as a capacity of deriving world-models, which then might provide a "database" for thinking, planning, and problem solving. Rather, it is emphasized that cognitive systems are always engaged in contexts of action that require fast selection of relevant information and constant sensorimotor exchange. In the context of such an action-oriented conceptual framework, investigation of the intrinsic dynamics of neural circuits becomes increasingly important. There is ample evidence that the processing of stimuli is controlled by top-down influences that strongly shape the dynamics of thalamocortical networks and constantly create predictions about forthcoming sensory events. Therefore, perceptual processing is increasingly considered as being active and highly selective in nature. Engel discusses recent neurobiological evidence supporting this "pragmatic turn" and the implications of this view for future research strategies in cognitive neuroscience.

Michel Le Van Quyen (chapter 9) presents the original approach, initially proposed by Francisco Varela, which is termed "neurophenomenology." The idea is to articulate rigorously controlled accounts of first-person lived experience with sophisticated third-person data concerning brain activity. We find here a leitmotif that is quite general in the paradigm of enaction, and that is manifested in several of the contributions to this book. When seeking to articulate two apparently distinct domains, it is not a question of hierarchically reducing one domain to the other; rather, the aim is to create the conditions for a fruitful circulation between the domains, each of which retains its autonomy, in a way that is mutually beneficial. We may call this leitmotif, to which we shall return, the way of *hermeneutical circulation.* This is not a mere abstract idea: in the precise case study presented by Le Van Quyen, he recounts how this approach provides valuable clues for identifying what is really relevant in the complex mass of neurobiological data, and conversely, how it enables epileptic patients to gain a new degree of control over their lives.

The first set of chapters we have presented, up to chapter 9, share the feature that the "point of entry" is a relatively low level of organization grounded in embodiment and neuronal processes; these chapters focus on the emergence of higher-level phenomena. With the next two chapters, concerned with language, we pass a watershed (which is, however, anything but a discontinuous break) toward a "point of entry" at a relatively

high level of organization, the focus now being on the articulation with underlying lower-level processes. Chapter 10 by Didier Bottineau is bold and original; it plunges straight into the question of lived experience as it is brought about by "languaging" (an appropriate revival of a neologism initially due to Maturana). Enaction is about the instant and eternity, the organ and the being, the individual and the environment, the self and the kin, the ego and the tribe, the species and life. So is language, spanning from the instant one-syllable order *Go!* to the questions of the origin and evolution of language and languages through all the manifestations and categories—conversations, texts, styles, genres, jargons, dialects, languages, lexicons, grammars. In accordance with the anchoring of enaction in experience, this chapter focuses mainly on the immediate experience of languaging, and occasionally broaches more general subjects like acquisition and evolution. Particularly interesting and challenging is the renewal of perspective on the questions of lexicons and grammars: far from being pregiven as in traditional (notably Chomskian) approaches, we see here how such structures can emerge in the actual practice of languaging.

Chapter 11, by Rafael E. Núñez, takes up the gauntlet of examining what happens with the enaction paradigm when addressing an area of cognition that, by definition, lacks a physical reality available for empirical observation. What happens with this paradigm when dealing with rigorous and precise cognitive entities that are entirely *imaginary*? In this chapter, he argues that such a case is provided by one of the most abstract and precise conceptual systems human beings have ever created: mathematics. In particular, he argues that mathematical infinity, as an object of cognition that by definition is not directly available to experience due to the finite nature of living systems, is an excellent candidate for fully exploring the power of enaction as a paradigm for cognitive science. His argument rests on the observation that language is a medium for the expression of *bodily* metaphors, and that this relation to embodiment, far from dissolving, is more relevant than ever in the case of the extension to purely abstract thought.

The last four chapters deal with questions that are usually considered as the exclusive reserve of the human and social sciences. A framework is provided by Véronique Havelange (chapter 12), who starts by examining how the phenomenology of Husserl, starting from a position of transcendental idealism, is lead by the *internal* logic of the phenomenological investigation to take into account elements such as time, the living body, the Other, worldly objects and culture; these elements are thus not merely constitut*ed*, they are irreducibly constitut*ive* of the

subjective, intersubjective and sociohistorical life of intentional consciousness. This leads to recognizing a "dual and mutual presupposition between science and the pre-donation of the world," giving rise to a hermeneutical circularity between phenomenology and cognitive science. And again, this is not merely an abstract petition of principle: Havelange illustrates this approach by referring to cutting-edge empirical research on perceptual supplementation.

In chapter 13, Diego Cosmelli and Evan Thompson address the topic of phenomenal selfhood and prereflective, intransitive self-consciousness, which is closely related to awareness of the body as subject. They raise the question of the minimal biological requirements for this type of phenomenal selfhood. Re-evaluating the notorious thought experiment of a "brain in a vat," they argue that (1) brain activity is largely endogenously and spontaneously generated, (2) this activity requires massive resources and regulatory processes from the rest of the body, and (3) this activity plays a crucial role in the life-regulation processes of the whole organism. They conclude that the "vat" would have to be in effect a surrogate body, so that the minimal biological substrate of phenomenal selfhood is not particular brain regions or areas, or even the brain alone, but some crucial subset of autonomous and interactive brain-body systems.

Chapter 14, by Benny Shanon, seeks to rehabilitate psychology as a full-fledged human science in its own right, liberated from an inferiority complex with respect to third-person natural science. To this end, Shanon proposes a reconsideration of the status of seven factors—the *context* of cognitive activity, the *medium* in which it is expressed, the *body,* the external physical *world,* the *social other,* the noncognitive faculties of *affect and motivation,* and *time*—which classical cognitivism typically regards as merely secondary. When the primary import of these factors is appreciated, one reaches the conclusion that rather than being the basis for cognition, representations are the products of cognitive activity, and that the basic capability of mind is not information processing and symbol manipulation but rather being and acting in the world. The locus of cognitive activity is not exclusively internal and mental, but rather external, taking place in the interface where organism and world meet. With this, the focus of psychological science shifts from the domain of the unconscious to that of the conscious. Shanon presents several lines of inquiry into the phenomenology of human consciousness: thought sequences, the systematic typology of experience, and a novel approach for the study of nonordinary states of consciousness. Together, these lead to the conceptualization of a general theory of consciousness.

In his previous work, Edwin Hutchins (1995) pointed out that first-generation cognitive science considered that human culture was a secondary phenomenon; and, in a spirit analogous to that of Shanon, proposed to turn this around and to consider that "culture" is a central feature of human cognition. He put particular emphasis on the importance of technical devices and *external* representations such as maps. In chapter 15, Hutchins takes up these themes and relates them explicitly to embodiment and the enaction framework, showing how these imply a new approach to the analysis of ongoing activity. He then uses this approach to sketch a speculative experimental analysis of an example of real-world problem solving that includes a moment of Aha! insight. Finally, he points out that external representations must be "enacted" in order to make sense, and discusses how this may help us explain how high-level cognitive processes can arise from low-level perceptual and motor abilities. It is to be noted that this case study well illustrates the "hermeneutical circulation" between enactive cognitive science and the human and social sciences (in this case, cultural anthropology) called for by Havelange.

To conclude this brief introduction, we would like to say a few words in order to situate the paradigm of enaction with respect to the numerous currents and schools of thought, past and present, with which it has natural relations of affinity. The references at the end of each chapter give an indication of these related currents; they are however so numerous that an attempt at a commented list would be both incomplete and inevitably superficial. Instead, we shall rather proceed thematically, by identifying three salient characteristics that mark the originality and the specificity of enaction as a paradigm.

The first of these three themes is the relation between first-person lived experience and third-person natural science. The proposal that cognitive science should seriously take into account the dimension of lived experience from a first-person point of view was one of Francisco Varela's most audacious and original contributions (Varela, Thompson, and Rosch 1991; see also chapter 9, this volume). This feature distinguishes the perspective of enaction from other related schools of thought, notably Gibsonian ecological psychology (Gibson 1979), which (in certain interpretations at least) is more than compatible with enaction but which explicitly eschews the first-person dimension. Even the sensorimotor contingency theory (O'Regan and Noë 2001), which does explicitly aim at explaining the "qualia" of lived experience, eschews first-person accounts (and hence phenomenology) as such. Conversely, phenomenology itself (which is of course grounded in first-person experience) is typically (although not

necessarily, as argued by Havelange in chapter 12) ill at ease in taking fully into account the perspective of third-person natural science. One possible approach, among others, is to ask the question: "How does an experiencing subject *appear* to an external observer?" The French philosopher Raymond Ruyer (1937) has made a bold and original proposal: on his account, the brain *is* neither more nor less than the appearance of consciousness for an external observer. In its original form, this proposal is not entirely satisfactory (Barbaras 2007), but it does open up new perspectives for a way of doing research in neuroscience that would fully live up to its role in cognitive science.

To conclude on this theme, a modest disclaimer is in order here. None of this amounts to claiming that enaction has found a definitive "final solution" to the problem of connecting first-person and third-person accounts, but we do consider that this very difficult question most definitely is on the agenda of cognitive science.

The second theme is the ambition of enaction as a paradigm to provide an encompassing framework for articulating the many domains and levels of organization that are involved in cognitive science. This is perhaps most clearly expressed in the opening text by Stewart, which runs the whole gamut from physicochemical dissipative structures, basic biological metabolism, and autopoiesis through to specifically human culture and historical consciousness. An aspect that has been gaining increasing attention over the last two or three years is the question of *social cognition.* An issue that is currently the object of lively debate is the articulation between "micro-level" processes—typically dyadic or triadic interactions between individuals—and the "macro-level" phenomena of social structures and human society as a whole. At this macro level, we may especially note the key role accorded to a thematization of technical artifacts and systems, and the modes of their appropriation and actual use by human agents (Havelange 2005). This is indeed the hallmark of the "Compiegne School," according to which "Technology is Anthropologically Constitutive." Integrated into the paradigm of enaction, this marks an important difference from purely biological approaches on one hand, but also from much work in the more traditional human and social sciences, in which the *material* dimension is rarely taken fully into account.

Coming back to the macro/micro debate, it may be useful to note that an analogous debate has already occurred in the realm of the social sciences. Durkheim, widely recognized as the "founding father" of modern sociology, laid emphasis on the importance (and reality!) of global social norms and institutions. Garfinkel (1967), who introduced the notion of "ethnomethodology," focused attention on much smaller-scale processes

involving the short-term dynamics of interactions at the individual level. Perhaps the most fruitful resolution of this debate lies in the proposal by Giddens (1976) that micro-level and macro-level approaches should be seen as complementary rather than antagonistic. Macro-level social structures are continuously "enacted" by individual actions and interactions; it is in this way that they (slowly) evolve over historical time. On the other hand, for each new generation of individuals, social structures are "always already there," and fundamentally condition the processes of individual development and "socialization."

To conclude on this second theme, another important disclaimer is in order. The fact that enaction has the ambition of providing an "encompassing framework" does *not* mean that if this paradigm develops to its fullest potential, it would thereby render other, more focused approaches redundant. Reductionist eliminativism does exist—in cognitive science, most notably with respect to the view that a full development of cerebral neuroscience would supersede all other approaches to cognition. But the spirit of the paradigm of enaction is quite the opposite of this; rather, the aim is to organize a *hermeneutical circulation* between diverse approaches, in which each retain their autonomy and their validity.

The third theme is that of reflexivity. The activities of a community of cognitive scientists are, *themselves,* a form of cognition. It follows that if a paradigm in cognitive science is thoroughgoing (and enaction certainly aims at this), it cannot avoid being reflexive and applying to itself. This complexity is not without appeal, and may indeed be considered fascinating, but it is salutary to recognize that it is not without its own difficulties. Russell's paradox[2] is there to remind us that reflexivity has its dangers, as it can so easily introduce fatal contradictions. Husserl, evoking the "paradox of anthropology," was well aware of these formidable difficulties. One way of illustrating the difficulty is based on Maturana's fable of the "man in the submarine." His friends on the shore admire the skill with which he avoids reefs and shoals and brings the submarine safely into port during a storm; they congratulate him. But he retorts: "'Shoals'? 'Reefs'? 'Storm'? I don't know what you're talking about. All *I* know are the readings on dials, and the levers I must push and pull so as to maintain invariant certain relations between the meter-readings." This is the point of the difficult notion of "operational closure" (chapter 2, this volume): it is vital to maintain a clear distinction between what can be perceived by an external observer, and what can be perceived by the organism itself. The problem is that when we ambition to apply the whole scheme of enaction *to ourselves as cognitive scientists*, it would seem that we are disobeying this injunction and hence running the risk of introducing a fatal contradiction;

of trying to do precisely what the principle of operational closure deems to be impossible.

There are, let it be said, several possible lines of attack on this difficult problem. In *The Tree of Knowledge*, Maturana and Varela quite deliberately adopt a form of presentation, which comes full circle back to its own starting point. A social-constructivist approach to scientific activity (Latour and Woolgar 1979) is itself a scientific study, and therefore necessarily applies to itself. The conception of establishing a "hermeneutical circle," notably between static phenomenology and genetic phenomenology (chapter 12, this volume) also shares this reflexive character. Finally, the concluding remarks in the chapter by Stewart (see section 1.3) quite explicitly evoke this reflexive feature: we may start out with elementary forms of life; going through all the increasingly complex forms of life that have arisen on Earth, we end up with . . . the biologist studying elementary forms of life. In other words, the enactive topology is rather like that of a Möbius strip: by going full circle, we end up at the starting point—but with the *object* of scientific study having changed sides on the subject-object relation, becoming itself the *subject* of scientific enquiry.

We shall close this introduction, then, with another modest disclaimer: the paradigm of enaction, at least in its present state, cannot pretend to have already a satisfactory solution to these problems. It does, however, at least *admit* the issue of reflexivity as an interesting and valid question; it also presents a promising attempt at providing an encompassing account of cognition from cell to society, and it adopts as a methodological pillar, despite many unresolved issues, the need for circulation between first-person experience and third-personal scientific methods. These features are sufficient to characterize it distinctively compared to other trends and approaches in cognitive science.

Notes

1. The book is based on an International CNRS Summer School organized by the Association pour la Recherche Cognitive (ARCo), held from May 29 to June 3, 2006, in Ile d'Oléron, France, and attended by sixty participants. The climate of vigorous discussion during that meeting provided the momentum for this book. Several chapters are the outcome of those interactions and it was only natural to extend the conversation to a wider community. A number of additional contributions address topics and points of view that could not be fully covered in the summer school.

2. This paradox is both simple and amusing. A barber proposes to shave all the men in town who do not shave themselves. The reflexive conundrum is then: does the barber shave himself? If he does not, he should—but if he does, he should not!

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