We Are Live Creatures: Embodiment, American Pragmatism, and the Cognitive Organism

Mark Johnson and Tim Rohrer

markj @ oregon.uoregon.edu and rohrer @ cogsci.ucsd.edu

citation information:
Johnson, Mark and Tim Rohrer. "We Are Live Creatures: Embodiment, American Pragmatism, and the Cognitive Organism." In *Body, Language, and Mind, vol. 1*, 17-54. Zlatev, Jordan; Ziemke, Tom; Frank, Roz; Dirven, René (eds.). Berlin: Mouton de Gruyter, 2007.
(portions of this article later appeared in chapters 7-9 of Mark Johnson's book *The Meaning of the Body* (2007).

Abstract

The philosophical tradition mistakenly asks how the inside (i.e. thoughts, ideas, concepts) can represent the outside (i.e., the world). This trap is a consequence of the view that mind and body must be two ontologically different entities. On this view the problem of meaning is to explain how disembodied "internal" ideas can represent "external" physical objects and events. Several centuries have shown that given a radical mind-body dichotomy, there is no way to bridge the gap between the inner and the outer. When "mind" and "body" are regarded as two fundamentally different *kinds*, no third mediating thing can exist that possesses both the metaphysical character of inner, mental things and simultaneously possesses the character of the outer, physical things.

Embodied Realism, in contrast to Representationalist theories, rejects the notion that mind and body are two ontologically distinct kinds, and it therefore rejects the attendant view that cognition and language are based on symbolic representations inside the mind of an organism that refer to some physical thing in an outside world. Instead, the terms "body" and "mind" are simply convenient shorthand ways of identifying aspects of ongoing organism-environment interactions—and so cognition and language must be understood as arising from organic processes. We trace the rejection of this mind-body dualism from the philosopher-psychologists known as the early American pragmatists (James and Dewey) forward through recent cognitive science (such as Varela, Maturana, Edelman, Hutchins, Lakoff, Johnson, Brooks). We argue that embodied realism requires a radical reevaluation of the classical dualistic metaphysics and epistemology—especially the classical Representationalist theory of mind—and we conclude by investigating the implications for future investigations for a new, pragmatically-centered cognitive science.

Keywords: Image schema, metaphor, representationalism, neurobiology, cognitive linguistics, semantics, embodiment, pragmatism, cognitive science

1. Introduction: What difference does embodied realism make?

When a young child crawls toward the fire in the hearth and a mother snatches up the child before the child gets burned, is that cognition? When a team of British mathematicians decodes enemy ciphers during wartime, is that cognition? When ants carrying food back to their nest lay down chemical signals and thereby mark trails to a food source, is that cognition?

Note the commonalities among these situations. In each case the body (both individual and social) is in peril. First, the well-being and continued successful functioning of the organism is at risk. Action must be undertaken to ensure the continued flourishing of the living, physical, individual body of the organism. To survive and flourish, the organism must make adjustments in its way of acting, both within its current environment and in its relations with other creatures. The child must be snatched from the imminent danger of the flames, the mathematicians desperately work to prevent their country from being overrun by the enemy, and the ants must find food and bring it back to the queen in order for the colony to survive. Second, note that in each case the cognition is social, composed of multiple organisms co-operating in response to current or anticipated problems posed by the environment. That environment is not merely physical but also includes the social "body"—whether the family, the nation or the ant colony—whose survival and flourishing is at risk. And finally, note that each of these situations have been taken by theorists as emblematic of cognition *par excellance* (Dewey 1925; Hodges 1983: 160-241, Deneubourg et al. 1983; Brooks and Flynn 1989).

The importance of embodiment in cognition is now widely appreciated in the cognitive sciences, yet there remains considerable debate as to what the term "embodiment" actually means (Rohrer 2001a; in press; Ziemke 2003; Anderson 2003). Is "the body" merely a physical, causally determined entity? Is it a set of organic processes? Is it a felt experience of sensations and movement? Is it the individual physical body, or does it include the social networks such as families without which it would cease to exist? Or is the body a socially and culturally constructed artifact? In this chapter, we argue that each of these views contributes something important to an adequate theory of embodied cognition, and that a proper understanding of embodiment can be found within the philosophical context first elaborated in early American Pragmatism in the works of thinkers such as William James and John Dewey. As we see it, embodiment theory inherits several key tenets of how these Pragmatist philosophers viewed cognition:

(1) Embodied cognition is the result of the evolutionary processes of variation, change, and selection.
(2) Embodied cognition is situated within a dynamic ongoing organism-environment relationship.
(3) Embodied cognition is problem-centered, and it operates relative to the needs, interests, and values of organisms.
(4) Embodied cognition is not concerned with finding some allegedly perfect solution to a problem, but one that works well enough relative to the current situation.
(5) Embodied cognition is often social and carried out cooperatively by more than one individual organism.

Note that the Pragmatists advance a radically different view of cognition than the one we are most familiar with from classical cognitive science, where it is assumed that cognition consists of the application of universal logical rules that govern the manipulation of "internal" mental symbols, symbols that are supposedly capable of representing states of affairs in the "external" world. Fodor summarizes this theory as follows:

> What I am selling is the Representational Theory of Mind . . . At the heart of the theory is the postulation of a language of thought: an infinite set of 'mental representations' which function both as the immediate objects of propositional attitudes and as the domains of mental processes (Fodor 1987: 16-17).

These internal representations in the "language of thought" acquire their meaning by being "about"—or referring to—states of affairs in the external world. Fodor acknowledges that his Representationalist theory of meaning requires "a theory that articulates, in nonsemantic and nonintentional terms, sufficient conditions for one bit of the world to *be about* (to express, represent, or be true of) another bit" (Fodor 1987: 98). Typically the first "bit" would be a symbol in the internal language of thought while the second "bit" that it represents might be either some thing or event in the external world or else a brain state underlying a conception of some fictive entity or scene.

The internal/external split that underlies this view presupposes that cognition could be detached from the nature and functioning of specific bodily organisms, from the environments they inhabit, and from the problems that provoke cognition. Given this view, it would follow that cognition could take place in any number of suitable media, such as a human brain or a machine. This theoretical viewpoint, functionalism, was instrumental in the developing the first electronic calculating machines and general-purpose computers. In fact, these machines were originally developed by the British military to reduce the tedious workload of military mathematicians (or human "computers"—in the sense of humans who compute). But this thought experiment did not end merely with offloading the tedium of calculation onto electronic machines. From its original conception in the work of Alan Turing (1937), the idea of a universal computing machine became the metaphor of choice for future models of the brain. For example in Newell and Simon's (1976) conception of the brain as a physical symbol system, they consider the human brain to be just a specific instance of a Turing-style universal machine. In short, for classical cognitive science cognition is defined narrowly as mathematical and logical computation with intrinsically meaningless internal symbols that can supposedly be placed in relation to aspects of the external world.

The Pragmatist challenge to classical cognitive science should come as no surprise, since one of the Pragmatists' chief targets was the tendency within the philosophical tradition to assume that what demarcates "rational" humans from "lower" animals is the supposedly unique ability of humans to engage in symbolic representation between internal thoughts/language and the external world. The remedy offered by the Pragmatists is based on their view that *cognition is action*, rather than mental mirroring of an external reality. Moreover, cognition is a particular kind of action—a response strategy that applies some measure of forethought in order to solve some practical real-world problem. During World War II the practical problem of breaking the German codes was of utmost importance to the British war effort, and this led to the development of a series of machines (the Bombes) which could try a vast number of possible cipher keys against intercepted German communications. These decoding machines were among the predecessors of the modern computer. Early computers were designed to model human action—*computing* possible cipher keys—so that machines would replace human labor (Hodges 1983: 160-241).

However, this success in the modelling of a very specific intellectual operation was soon mistakenly regarded as the key to understanding cognition in general. If one thinks that mathematical and logical reasoning is what distinguishes human beings from other animals, one might erroneously assume that any computational machine that could model aspects of this peculiarly human trait could also be used to model cognition in general. Hence the MIND AS COMPUTER metaphor swept early (first-generation) cognitive science. This is a disembodied view of rationality. By contrast, on the Pragmatist view, our rationality emerges from, and is shaped by, our embodied nature. Thus, Dewey famously asserted that "to see the organism *in* nature, the nervous system in the organism, the brain in the nervous system, the cortex in the brain is the answer to the problems which haunt philosophy" (Dewey 1925: 198).

In the following sections we show how the Pragmatist view of cognition as action provides an appropriate philosophical framework for the cognitive science of the embodied mind. We begin by describing the non-dualistic, non-representational view of mind developed by James and Dewey. Their understanding of situated cognition is reinforced by recent empirical research and developments within the cognitive sciences. We cite evidence from comparative neurobiology of organism-environment coupling ranging from the amoeba all the way up to humans, and we argue that in humans this coupling process becomes the basis of meaning and thought. We describe the patterns of these ongoing interactions as *image schemas* that ground meaning in our embodiment and yet are not internal representations of an external reality. This leads to an account of an emergent rationality that is embodied, social, and creative.

2. James and Dewey: The Continuity of Embodied Experience and Thought

In many ways the American Pragmatist philosophers James and Dewey provide us today with exemplary non-reductionist and non-representationalist models of embodied mind. Their models combined the best biology**,** psychology and neuroscience of their day with nuanced phenomenological description and a commitment that philosophy should address the pressing human problems of our lives. James and Dewey understood something taken for granted in contemporary biological science: cognition emerges from the embodied processes of an organism that is constantly adapting to better utilize relatively stable patterns within a changing environment. One problem for such a naturalistic account of mind is to explain how meaning, abstract thinking, and formal reasoning could emerge from the basic sensorimotor capacities of organisms as they interact with the environment and each other.

The fundamental assumption of the Pragmatists' naturalistic approach is that everything we attribute to "mind"—perceiving, conceptualizing, imagining, reasoning, desiring, willing, dreaming—has emerged (and continues to develop) as part of a process in which an organism seeks to survive, grow, and flourish within different kinds of situations. As James puts it:

> Mental facts cannot be properly studied apart from the physical environment of which they take cognizance. The great fault of the older rational psychology was to set up the soul as an absolute spiritual being with certain faculties of its own by which the several activities of remembering, imagining, reasoning, and willing, etc. were explained, almost without reference to the peculiarities of the world with which these activities deal. But the richer insight of modern days perceives that our inner faculties are *adapted* in advance to the features of the world in which we dwell, adapted, I mean, so as to secure our safety and prosperity in its midst (James 1900: 3).

This evolutionary embeddedness of the organism within its changing environments, and the development of thought in response to such changes, ties mind inextricably to body and environment. The changes entailed by such a view are revolutionary. From the very beginning of life, the problem of knowledge is *not* how so-called internal ideas can re-present external realities. Instead, the problem of knowledge is to explain how structures and patterns of organism-environment interaction can be adapted and transformed to help deal constructively with changing circumstances that pose new problems**,** challenges, and opportunities for the organism. On this view, mind is never separate from body, for it is always a series of bodily activities immersed in the ongoing flow of organism-environment interactions that constitutes experience. In Dewey's words:

> Since both the inanimate and the human environment are involved in the functions of life, it is inevitable, if these functions evolve to the point of thinking and if thinking is naturally serial with biological functions, that it will have as the material of thought, even of its erratic imaginings, the events and connections of this environment (Dewey 1925: 212-213).

Another way of expressing this rootedness of thinking in bodily experience and its connection with the environment is to say that there is no rupture in experience between perceiving, feeling, and thinking. In explaining ever more complex "higher" functions, such as consciousness, self-reflection, and language use, we do not postulate new ontological kinds of entities, events, or processes that are non-natural or super-natural. More complex levels of organic functioning are just that—levels—and nothing more, although there are emergent properties of "higher" levels of functioning. Dewey names this connectedness of all cognition the *principle of continuity,* which states that "there is no breach of continuity between operations of inquiry and biological operations and physical operations. 'Continuity' ... means that rational operations *grow out of* organic activities, without being identical with that from which they emerge" (Dewey 1938: 26)

What the continuity thesis entails is that any explanation of the nature and workings of mind, even the most abstract conceptualization and reasoning, must have its roots in our organismic capacities for perception, feeling, object manipulation, and bodily movement. Furthermore, social and cultural forces are required to develop these capacities to their full potential, including language and symbolic reasoning. Infants do not speak or discover mathematical proofs at birth; Dewey's continuity thesis requires both evolutionary and developmental explanations. For James and Dewey, this meant that a full-fledged theory of human cognition must have at least three major components:

(1) There must be an account of the emergence and development of meaningful patterns of organism-environment interactions—patterns of sensorimotor experience shared by all organisms of a certain kind and meaningful for those organisms. Such patterns must be tied to the organism's attempts to function within its environment**.**

(2) There must be an account of how we can perform abstract thinking using our capacities for perception and motor response. There would need to be bodily processes for extending sensorimotor concepts and logic for use in abstract reasoning, as well as an account of how the processes embodying such abstract reasoning capacities are learned during organismic development. This story has at least two parts: (a) an evolutionary and physiological account explaining how an adult human being's abstract reasoning utilizes the brain's perceptual and motor systems, and (b) a developmental and anthropological account of how social and cultural behaviors educate the sensorimotor systems of successive generations of children so that they may speak and perform abstract reasoning.

(3) There must be an account of how values and behavioural motivations emerge from the organism's ongoing functioning. This explanation will include (a) the physical and social makeup of organisms, (b) the nature of their emotional responses, and (c) the kinds of environments (e.g., material, social, cultural) they inhabit. In the present space we are able to offer only a very compressed and partial treatment of such an account.

3. Organism-Environment Coupling

3.1 Maturana and Varela: From Chemotaxis to the Nervous System

Dewey's principle of continuity states that there are no ontological gaps between the different levels of an organism's functioning. One way to see what this entails is to survey a few representative types of organism-environment couplings, starting with single-cellular organisms and moving up by degrees to more complex animals. In every case we can observe the same adaptive process of interactive co-ordination between a specific organism and recurring characteristics of its environment. But does that mean that we can trace human cognition all the way back to the sensorimotor behavior of single-cellular organisms? On the face of it, this seems preposterous—viewed from an evolutionary biologist's perspective, there are clear differences in the size, complexity, and structural differentiation of human beings as compared with single-cellular organisms like bacteria. Single-cellular organism behavior is not ordinarily relevant to the behavior of multi-cellular organisms—except insofar as there might be structural morphological analogies between the sensorimotor activity of single-cellular organisms and particular sensorimotoric cells within the multi-cellular body.

Just this sort of morphological analogy plays a key role in Maturana and Varela's argument that central nervous systems evolved in multi-cellular organisms to co-ordinate sensorimotor activity (1998: 142-163). In a single-cellular organism locomotion is achieved by dynamically coupling the sensory and motoric surfaces of the cell membrane. When an amoeba engulfs a protozoan, its cell membranes are responding to the presence of the chemical substances that make up the protozoan, causing changes in the consistency of the amoeba's protoplasm. These changes manifest as pseudopods—digitations that the amoeba extends around the protozoan as it prepares to feed upon it. Similarly, certain bacteria have a tail-like membrane structure called a flagellum that is rotated like a propeller to move the bacterium. When the flagellum is rotated in one direction the bacterium simply tumbles, while reversing the direction of rotation causes the bacterium to move. If a grain of sugar is placed into the solution containing this bacterium, chemical receptors on the cell membrane sense the sugar molecules. This causes a membrane change in which the bacterium changes the direction of rotation of its flagellar propeller and gradually moves toward the greatest concentration of the sugar molecules (chemotaxis). In both cases, changes in the chemical environment cause sensory perturbations in the cellular membrane, which invariably produces movement. The key point here is that, without anything like an internal representation, single-cellular organisms engage in sensorimotor co-ordination in response to environmental changes. Even at this apparently primitive level, there is a finely tuned ongoing coupling of organism and environment.

Multi-cellular organisms also accomplish their sensorimotor co-ordination by means of changes in their cell membranes. However, the cellular specialization afforded by a multi-cellular organism means that not every cell needs to perform the same functions. Maturana and Varela (1998) discuss the example of an evolutionarily ancient metazoic organism called the Hydra (a coelenterate). The Hydra, which lives in ponds, is shaped like a two-layered tube with four or six tentacles emanating from its mouth. On the inside layer of the tube, most cells secrete digestive fluids, while the outside layer is partly composed of radial and longitudinal muscle cells. Locomotion is accomplished by contracting muscle cells along the body of the organism: some of these contractions cause changes in the hydrostatic pressure within the organism, changing its shape and direction of locomotion.

Between the two layers of cells, however, are specialized cells—neurons—with elongated membranes that can extend over the length of the entire organism before terminating in the muscle cells. These tail-like cellular projections are the axons, and evolutionarily speaking they are the flagella of the multi-cellular organism[1]. Changes in the electrochemical state in other, smaller cellular projections of the cells (the dendrites) cause larger changes in the electrochemical state of the axonal membrane, which in turn induces the muscle cells to contract. These neural signals typically originate in either the tentacles or the "stomach" of the Hydra, such that their electrochemical state responds to the molecules indicating the presence or absence of food and/or excessive digestive secretions. These neurons consistently terminate in the longitudinal and radial muscles that contract the Hydra body for locomotion or for swallowing. The topology of how the nerve cells interconnect is crucially important: when touched, a chain of neurons fire sequentially down a Hydra tentacle toward its mouth and cause the muscle cells to curl the tentacle about its prey even as its mouth begins to open. The Hydra does not "represent" an external world; instead, the structural coupling between organism and environment allows the Hydra to contract the correct muscles to swallow, or to move up and left, or right and down. Like the Hydra opening its mouth as a reflexive part of bringing food to it with its tentacles, we humans think in order to act and we act as *part of* our thinking—cognition is action. But how is it that we humans can learn new behaviors, while the Hydra generally cannot?

3.2 From Neural Maps to Neural Plasticity

Although still surprisingly continuous with the Hydra, human cognition is a little more similar to what happens in frogs, owls and monkeys in that all of these organisms have nervous systems that include neural maps and adaptive neural plasticity. Frogs have a certain regularly occurring pragmatic problem—they need to extend their tongues to eat a fly—which was the subject of a classic experiment in the early history of neurobiology (Sperry 1943). When a frog is still a tadpole, it is possible to rotate the frog's eye 180 degrees, making sure to keep the optic nerve intact. The tadpole is then allowed to develop normally into a frog. The frog's tongue extends to exactly the opposite point of the frog's visual field from where the fly is located. No amount of failure at catching the fly will teach the frog to move its tongue differently; the frog acts entirely on the basis of the rewired neural connections between the retinal image and the tongue muscles. Maturana and Varela conclude that *for the frog* "there is no such thing as up or down, front and back, in reference to an outside world, as it exists for the observer doing the study" (1998: 125-126). The frog has no access to our notion of the external world and our 180-degree rotation of its eye; it has only its experience of the world found in the neurons comprising its (experimentally inverted) retinal map.

One of the most profound findings in neuroscience is that nervous systems exploit topological and topographic organization. In other words, organisms build neural "maps." In neural maps, adjacent neural cells (or small groups of neural cells) fire sequentially when a stimulus in adjacent positions within a sensory field moves. For example, scientists have stimulated the frog's visual field and measured the electrical activity of a region of its brain to show that as one stimulates the frog's visual field, the neurons of its optic tectum will fire in co-ordination with the visual stimulus. Fraser (1985) covered the frog's optic tectum with a 24

---

[1] Recent research shows that this may be more than a surface morphological analogy: all microtubular cellular projections stem from a common ancestor (Erickson et al. 1996; Goldberg 2003).

electrode grid, with each electrode recording electrical activity that was the sum of the signals from a receptive field containing many optic nerve fiber terminals. When a point of light was moved in a straight line from right to left and then from bottom to top in the frog's right visual field, the electrode grid recorded neuronal activity in straight lines, firing sequentially, first from the rostral (front) to the caudal (back) and then from the lateral to the medial. We call this the frog's retinal (or retinotectal) map because it encodes environmental visual stimuli in a topographically consistent manner. The spatial orientation of this topography is rotated in various ways. Thus visual right-to-left has become front-to-back and so on, but the topographic mapping between movement in the vertical visual plane and the plane of the retinotectal neural map remains consistent. Even though there is considerable spatial distortion in the neural map, the key relational structures are preserved. In some other cases, such as some auditory maps and color maps, where the correspondences can be less about shape and position, the organization is more properly called topologic than topographic, but the organizing principle of the neural mapping of sensation still holds.

The degree to which such neural maps might be plastic has been the subject of much recent study. In the case of rotating the eye of the frog, Sperry performed a radical and destructive intervention that is outside the realm of "normal" Darwinian deviation—in other words, if this were to occur by natural selection such a frog would die quickly without passing on its genes. However, interventions which are less radical and perhaps more likely to occur in nature, such as cutting the optic nerve and destroying part of the optic tectum of a goldfish, result in a recovery of function in which the optic nerve axons regenerate to make a complete retinal map in the remaining part of the tectum (Gaze and Sharma 1970). Although radical interventions can "break" the neural maps, even the more evolutionarily determined neural networks exhibit some range of adaptive neural plasticity to environmental factors.

Plasticity is particularly profound in cross-modal neural maps. Consider another subtle environmental intervention: suppose we were to have an owl wear glasses that changed its perception of the visual field. Similar to the frog, owls have developed an extremely accurate method of attacking prey. The owl hears a mouse rustling on the ground and locates the mouse using the tiny difference in time it takes for a sound to reach one ear versus the time it takes the sound to reach the owl's other ear. This establishes the mouse's approximate position in the owl's retinotectal map, and the diving owl then visually confirms the exact location of its prey before it strikes. Knudsen and colleagues (Knudsen 2002; 1998) put prismatic glasses on adult and juvenile owls which distorted the owls' vision by 23 degrees. After 8 weeks with glasses, adults raised normally never learned to compensate, but juveniles were able to learn to hunt accurately. Moreover, when the glasses were reintroduced to the adult owls who had worn them as juveniles, they were then able to readjust to the glasses in short order**;** in other words, the prism-reared owls could successfully hunt with or without glasses.

These behavioural adaptations have anatomical underpinnings in the plasticity of the neural maps. When injected with an anatomical tracing dye, comparison of the neural arbors from normally-reared and prism-reared owls revealed a different pattern of axonal projections between auditory and spatial neural maps, "showing that alternative learned and normal circuits can coexist in this network" (Knudsen 2002: 325). In other words, in order to deal with wearing glasses, the owl brain had grown permanent alternative axonal connections in a cross-modal neural map of space located in the external nucleus of the inferior colliculus (ICX). The ICX neural arbor of prism-reared owls was significantly denser than in normally developing owls, with neurons typically having at least two distinct branches of axons (DeBello, Feldman and

Knudsen 2001). By contrast, the retinotectal maps of the visual modality alone do not exhibit the same plasticity, either in owls (whose retinotectum did not change) or in frogs. Analogous anatomical research on frogs reared and kept alive with surgically rotated eyes has shown that after five weeks, the retinotectal neural arbors initially exhibited a similar pattern of "two-headed axons"—that is, they had two major axonal branches. However, after ten weeks the older axonal connections are starting to decay and disappear, while after sixteen weeks no two-headed axons could be traced (Guo and Udin 2000). Apparently, the frog's single-modal retinotectal maps do not receive enough reentrant neural connections from other sensory modalities to sustain the multiple branching neural arbors found in the cross-modal map of the prism-reared owls.

Working on neural plasticity in adult squirrel and owl monkeys, Merzenich and colleagues (Merzenich et al. 1987; reviewed in Buonomano and Merzenich 1998) have shown that it is possible to dynamically reorganize the sensorimotor cortical maps subject to certain bodily constraints. Similar to the owls and frogs that grew dual arborizations, these monkeys exhibited a plasticity based on their brains' ability to select which parts of their neural arbors to use for various kinds of input. In a series of studies, Merzenich and colleagues altered the monkey's hand sensory activity by such interventions as (1) cutting a peripheral nerve such as the medial or radial nerve and (1a) allowing it to regenerate naturally or (1b) tying it off to prevent regeneration; (2) amputating a single digit; and (3) taping together two digits so that they could not be moved independently. The results show that cortical areas now lacking their previous sensory connections (or independent sensory input in the third condition) were "colonized" in a couple of weeks by adjacent neural maps with active sensory connections. In other words, the degree of existing but somewhat dormant neural arbor overlap was large enough to permit reorganization. And in the case of (1a), where the nerve was allowed to regenerate, the somatosensory map gradually returned to occupy a similar-sized stretch of cortex, albeit with slightly different boundaries. Learning in adults is accomplished in part by neural gating between redundant and overlapping neural arbors.

All of these examples of ontogenetic neural change suggest that there is a process of neural arbor selection akin to natural selection taking place in concert with specific patterns of organism-environment interactions. On precisely these grounds the neurobiologist Gerald Edelman (1987) has proposed a theory of "Neural Darwinism," or "neuronal group selection," to explain how such neural maps are formed in the organism's embryonic development. Different groups of neurons compete to become topological neural maps as they migrate and grow during neural development. Successful cortical groups, driven primarily by regularities in the environment passed on from those neurons that are closer to a sensory apparatus, will fire together and wire together in a process of axonal sprouting and synaptogenesis. Some neuronal groups will fail to find useful topological connections, and they eventually die and are crowded out by the successful neuronal groups, while others will hang on in something of an intermediate state of success (Edelman 1987: 127-140). In the adult organism, the latent axonal arbors from only partly successful attempts to wire together lay dormant, ready to reorganize the map as needed by means of further synaptogenesis. Edelman (1987: 43-47) calls these latent reorganizations of the neuronal groups *secondary repertoires*, as distinguished from their normal *primary repertoires*.

Like frogs, owls and monkeys, we humans have sets of visual, auditory, and somatosensory neural maps. The more obvious of these map perceptual space in fairly direct analogs—preserving topologies of pitch, the retinal field, color, the parts of the body, and so on—but subsequent maps preserve increasingly abstract topological structure (or even combinations of structure) such as object shape, edges, orientation, direction of motion, and even the particular degree of the vertical or horizontal. *Like the frog, we live in the world of our maps. Topologically speaking, our bodies are in our minds, in the sense that our sensorimotor maps provide the basis for conceptualization and reasoning.* We perceive the patterns of our daily organism-environment interactions in image-like fashion, constantly seeking out various topological invariances in those patterns that prove useful to us. In the following section we will show how our imagination and our reason are constituted by patterns of activation within these neural maps. But before proceeding to human cognition, we must first address why neural "maps" are not classical Representations.

3.3 Neural Maps are Not Internal Representations

Some people might suppose that talk of neural "maps" would necessarily engender Representationalist theories of cognition. On this view, the map would be construed as an internal representation of some external reality. But the account we have been giving *does not* entail any of the traditional metaphysical dualisms that underlie Representationalist views—dichotomies such as inner/outer, subject/object, mind/body, self/world. Such dichotomies might describe aspects of organism-environment interactions from an observer's perspective, but they do not indicate different ontological entities or structures. According to our interactionist view, maps and other structures of organism-environment co-ordination are prime examples of non-representational structures of meaning, understanding, and thought.[2]

Maturana and Varela (1998: 125-126) make this important philosophical point quite clear. We must not read our scientific or philosophical perspectives (i.e., our theoretical stance) on cognition back into the experience itself that we are theorizing about. We must not uncritically assume that distinctions we make in explaining a certain cognitive experience are thereby part of the person's experience. To do so is to fall prey to what James termed the "Psychologist's Fallacy." In observing something scientifically, one must always consider the standpoint of the scientist in relation to the object of study. When we use terms such as "retinal map," "pitch maps," "sensorimotor maps," "color maps" and so forth to describe the operations of various neural arrays in a frog's nervous system, or in human nervous systems, we are doing so from our standpoint as observers and theorists who can see mappings between those neural structures and our own experience of the "external world." But for the frog, and for the human in the act of perceiving, that map is the basis for its experience of the world. The map constitutes the sensorimotor experience of a certain part of the frog's world. The frog's neural map itself

---

[2] We are certainly not suggesting that neuroscientists should purge the term "representation" from their vocabulary. Nor are we suggesting that there is no sense in which it would be appropriate to say that some neuronal structure is a representation from the perspective of the scientist who is studying cognitive processes. For example, we do not object to neuroscientists saying that a particular neural map in the auditory cortex can "represent" various pitch relations among musical tones, though we prefer to employ more enactive terms such as "map" and "activation contours." However, such casual usage doesn't necessarily entail the Representational Theory of Mind that we are challenging here. Instead, we argue that Representationalism is based on a mistaken philosophical analogy (namely "the language of thought" framework in which a mental or brain state refers to the world much as a word supposedly simply refers to an object or a state-of-affairs in the world). In order to undermine such Representationalist theories, we argue that actual neural representations are perpetually situated in dynamic organism-environment interactions that are continually changing along experiential, developmental and phylogenetic timelines. Hence, it is a mistake to think that neural maps are representations in virtue of an immediate word-world referential mapping, whether that word is a linguistic entity or a mental entity in a "language of thought."

has its origin not in the immediate mappings that we observers see in the moment, but in a longitudinal evolutionary and developmental process during which those neural connections were "selected for" by Darwinian or neo-Darwinian mechanisms.

In short, what we (as scientists) theoretically recognize and describe as an organism's "maps" are not *for that organism* internal representations. Rather, what we call sensorimotor and somatosensory maps (whether in multi-cellular organisms, monkeys, or humans) are *for that organism* precisely the structures of its experienced world! Consequently, we must be careful not to be misled by philosophers of mind and language who would treat these maps as internal representations of external realities, thereby surreptitiously introducing an "inner/outer" split that does not exist in reality for the organism.

4. Ontological Continuity and Human Thought: Image Schemas and Amodal Perception

Since the earliest episodes of ancient Greek philosophy, humans have been distinguished from "brute" animals and all lower organisms by their supposedly unique capacity for abstract conceptualization and reasoning. According to this view, human reason is what makes it possible for us to form abstract mental representations that stand for and point to states of affairs that are either external to us or are not currently present in our experience (i.e., are past or future). But the Pragmatists' Continuity Thesis denies the inner/outer dichotomy upon which Representationalist theories are grounded. Consequently, the problem for an embodied view of cognition is how to explain our marvellous human feats of abstraction, reasoning, and symbolic interaction, yet without positing an ontological rupture between "lower" animals and humans.

The key, once again, is the coupling (the interactive co-ordination) of an organism (here, a human one) and its environment. Recurring adaptive patterns of organism-environment interaction are the basis for our ability to survive and flourish. In humans, these patterns are no more "internal" representations than they are in other creatures. Let us consider briefly some of the most basic kinds of structural couplings that make up a human being's experience of its world.

4.1 Image Schemas and Cross-modal Perception

The character of our experience is delineated in large part by the nature of our bodies and brains, the kinds of environments we inhabit, and the values and purposes we have. The patterns of our ongoing interactions (or "enactions" as Varela, Rosch, and Thompson (1991) have called them, to stress their active, dynamic character) define the contours of our world and make it possible for us to make sense of, reason about, and act reliably within this world. Thousands of times each day we see, manipulate, and move into and out of containers, so containment is one of the most fundamental patterns of our experience. Because we have two legs and stand up within a gravitational field, we experience verticality and up-down orientation. Because the qualities (e.g., redness, softness, coolness, agitation, sharpness) of our experience vary continuously in intensity, there is a scalar vector in our world. For example, lights can grow brighter or dimmer, stoves get hotter or cooler, iced tea gets sweeter as we add sugar. We are subject to forces that move us, change our bodily states, and constrain our actions, and all of these forces have characteristic patterns and qualities. We are bound inextricably to our world interactively (enactively) by means of these recurring patterns that are the very conditions for us to survive, grow, and find meaning. Without such patterns, and without neural maps of such characteristic patterns, each moment of our experience would be utterly chaotic, as though we had to make sense of our world from scratch, over and over again as each new moment arose.

What Johnson (1987) and Lakoff (1987) called "image schemas"[3] are precisely these stable recurring patterns of sensorimotor experience by which we engage a world that we can understand and act within to further our purposes. There are numerous sources of evidence for the existence of image schemas, ranging from experimental psychology to linguistics to developmental psychology. We hypothesize that these image schemas are neurally embodied as patterns of activation in and between our topological neural maps. Image schemas are thus part of our non-representational coupling with our world, just as barn owls and squirrel monkeys have image schemas that define their types of sensorimotor experience.

Image schematic structure is the basis for our understanding of all aspects of our perception and motor activities. An example from Lakoff and Nunez (2000) illustrates this image-schematic basis of spatial concepts in humans. What we call our concept *in* is defined for us by a CONTAINER image schema that consists generically of (1) a boundary that demarcates (2) an interior from (3) an exterior. When we say, "The car is in the garage," we understand the garage as a bounded space, we profile (Langacker 1986) the interior of that space, and we regard the car as what cognitive linguists call a *trajector* within that space, with the garage (as container) serving as a *landmark* in relation to which the trajector is located. Similarly, when we hear the sentence "Grandpa walked from the outhouse to the garage," we understand that situation via a SOURCE-PATH-GOAL schema that consists of (a) a starting point, (b) a destination (endpoint), and (3) a path from the starting location to the destination. In other words, the "from-to" construction is image-schematic. The English word "into" is understood via a superimposition of the SOURCE-PATH-GOAL schema on the CONTAINER schema, as follows:

- "in" activates a CCONTAINER Schema with the interior profiled.
- "to" activates a SOURCE-PATH-GOAL schema with the destination (endpoint) profiled.
- The destination (endpoint) is mapped onto the interior of the CONTAINER schema.
- We thus understand Grandpa's (as trajector) movement as beginning outside the garage (container) and terminating inside the garage (as landmark), as a result of motion along a path from the exterior to the interior.

"Into" in English is thus an elementary composition of two image schemas.

Image schemas are realized as activation patterns (or "contours") in human topological neural maps. As with much interdisciplinary research in the neurosciences, the evidence for this first emerged from intracranial neuronal recordings on monkeys and was later extended to humans via analogous neuroimaging studies. When Rizzolatti and colleagues (Fogassi et al 2001; see review in Rizzolatti, Fogassi and Gallese 2002) showed macaque monkeys visual imagery of another monkey grasping a banana with their hands, they were able to record activity from "mirror" neurons in the same areas of secondary somatomotor cortex that would be implicated if the monkey himself were performing the particular grasping action. Analogous human neuroimaging experiments (Buccino et al 2001) in which participants watched a video clip of another person performing an action showed increased activation in the human secondary somatomotor cortices that are known to map human hand and arm grasping motions. Along with Rizzolatti's colleague Gallese, we interpret these and related results as having shown that these

---

[3] Johnson and Lakoff were in turn particularly influenced by linguists publishing on spatial relation terms such as Talmy (1985) and Langacker (1986), though their hypotheses and evidence are explicitly multi-disciplinary.

neural maps contain image schematic sensorimotor activation patterns for grasping (see Gallese and Lakoff 2005).

An explicit attempt to model image schemas using known facts about our neural maps can be found within the neurocomputational modelling literature. Regier (1996) has developed what he calls "structured" or "constrained" connectionist neural models for a number of image schemas. "Constrained" neurocomputational connectionism builds into its neural models a small number of structures that have been identified in research on human visual and spatial processing. These include center-surround cell arrays, spreading activation, orientation-sensitive cells, and neural gating. Regier has shown how these constrained connectionist models of image schemas can learn spatial relations terms.[4]

There is also a growing body of research from developmental psychology suggesting that infants come into the world with capacities for experiencing image-schematic structures. Stern (1985) described certain types of experiential structures that infants are able to detect, and he argues, first, that these capacities form the basis for meaning and the infant's sense of self; and, second, that these capacities continue to play a central role in meaning, understanding, and thinking even in adults who are capable of propositional thinking. Let us briefly consider two of these basic structures: (1) cross-modal perception, and (2) vitality affect contours.

Stern begins with a well-known experiment (Meltzoff and Borton 1979) in which blindfolded infants were given one of two pacifiers to suck. One was the typical smooth pacifier, while the other had protruding nubs. When the blindfolds were removed and smooth and nubbed pacifiers were placed on either side of the infant's head, most of the time (roughly 75%) the infant would attend to the nipple of the pacifier just sucked**.** Based on this and other studies (e.g. Lewkowicz and Turkewitz 1981), Stern suggests that

> Infants thus appear to have an innate general capacity, which can be called *amodal perception*, to take information received in one sensory modality and somehow translate it into another sensory modality. . . .
>
> These abstract representations that the infant experiences are not sights and sounds and touches and nameable objects, but rather shapes, intensities, and temporal patterns—the more "global" qualities of experience (Stern 1985: 51).

Although he speaks of these structures of cross-modal perception as amodal, abstract "representations", Stern also makes it clear that these perceptual structures are not inner mirrorings of external things but rather are the contours of the infant's experience: the cross-modal shapes, intensities and temporal patterns that we call image schemas.

Like infants, we adults have a ROUGH/SMOOTH image schema, which we can use as we anticipate the change in surface texture as we walk. For example, we can see where we will step from the rough carpet of the hallway onto the slippery tile of the bathroom, and we transfer this information from the visual to the somatomotor system so that our feet will not slip. Such patterns of cross-modal perception are especially clear examples of how image schemas differ from being just a topographically mapped image in a neural map; they are sensorimotoric patterns of experience which are instantiated in and coordinated between unimodal neural maps. Our image schematic experience may, as in the case of the owl, become instantiated in its own cross-modal neural map; or, as in the case of monkeys, it might consist of coordinated activation patterns between a network of more modal neural maps, including possibly calling on the

---

[4] This does not, of course, prove that human cognition necessarily works this way, but Regier's use of computational neural models built on known human neural architectures offers distinct advantages over traditional PDP connectionist models. Moreover, Regier's models can be appropriated into programs that allow robots to perform certain bodily movements.

secondary rather than primary repertoires of those maps. We predict that cases analogous to each will be observed in human neuroanatomical studies.

A second type of pattern that makes up the infant's (and adult's) image-schematic experience is what Stern (1985; Stern et al. 1987) calls "vitality affect contours." Stern illustrates this with the notion of a "rush," or the swelling qualitative contour of a felt experience. We can experience an adrenaline rush, a rush of joy or anger, a drug-induced rush, or the rush of a hot-flash. Even though these rushes are felt in different sensory modalities, they are all characterizable as a rapid, forceful building up or swelling contour of the experience across time. Stern notes that understanding how such affect contours are meaningful to creatures like us gives us profound insight into meaning generally, whether that meaning comes via language, vision, music, dance, touch, or smell. We crave the emotional satisfaction that comes from pattern completion, and witnessing even just a portion of the pattern is enough to set our affect contours in motion. The infant just needs to see us *begin* to reach for the bottle, and she already begins to quiet down—the grasping image schema does not even need to be completely realized in time before the infant recognizes the action. When as adults we hear a musical composition building up to a crescendo, this causes increasing emotional tension that is released at the musical climax. The emotional salience of the vitality affect contours in image schemas shows that image schemas are not mere static "representations" (or "snapshots") of one moment in a topographic neural map (or maps). Instead, image schemas proceed dynamically in and through time.

To summarize, image schemas can be characterized more formally as:

(1) recurrent patterns of bodily experience,
(2) "image"-like in that they preserve the topological structure of the perceptual whole, as evidenced by pattern-completion,
(3) operating dynamically in and across time,
(4) realized as activation patterns (or "contours") in and between topologic neural maps,
(5) structures which link sensorimotor experience to conceptualization and language, and
(6) structures which afford 'normal' pattern completions that can serve as a basis for inference.

Image schemas constitute a preverbal and pre-reflective emergent level of meaning. They are patterns found in the topologic neural maps we share with other animals, though we as humans have particular image schemas that are more or less peculiar to our types of bodies. However, even though image schemas typically operate without our conscious awareness of how they structure our experience, it is sometimes possible to become reflectively aware of the image-schematic structure of a certain experience, such as when I am consciously aware of my cupped hands as forming a container, or when I feel my body as being off balance.

4.2 Abstract conceptualization and reasoning

Pragmatism's Continuity Thesis claims that we must be able to move, without any ontological rupture, from the body-based meaning of spatial and perceptual experience that is characterizable by image schemas and affect contours, all the way up to abstract conceptualization, reasoning, and language use. Although there is not yet any fully worked out theory of how all abstract thought works, some of the central mechanisms are becoming better understood. One particularly important structure is *conceptual metaphor* (Lakoff and Johnson 1980; 1999). The most sweeping claim of Conceptual Metaphor Theory (CMT) is that what we call "abstract" concepts are defined by systematic mappings from bodily-based sensorimotor source domains onto abstract target domains. These metaphor mappings are found in patterns motivated by image schematic constraints—for example, if we map an interior from the source domain, we can expect to map the exterior as well; if we have source and destination mappings, we can expect a path mapping.

Consider the sentence “We have a long way to go before our theory is finished.” Why can we use the phrase “a long way to go,” which is literally about distance in motion through space, to talk about the completion of a mental project (i.e., developing a theory)? The answer is that there is a conceptual metaphor PURPOSEFUL ACTIVITIES ARE JOURNEYS, via which some cultures understand progress toward some nonphysical goal as progress in moving toward a destination. The metaphor consists of the following conceptual mapping:

The PURPOSEFUL ACTIVITIES ARE JOURNEYS METAPHOR

Source (motion in space)	>>>>	*Target (mental activity)*
Starting point A	>>>>	Initial state
Ending location B	>>>>	Final State
Destination	>>>>	Purpose to be achieved
Motion from A to B	>>>>	Process of achieving purpose
Obstacles to motion	>>>>	Difficulties in achieving goals

This conceptual mapping also makes use of one of our culture’s most basic metaphors for understanding the passage of time, in which temporal change is understood metaphorically as motion along a path to some location. In this metaphor, the observer moves along a time line, with the future arrayed as the space in front of her and the past as the space behind. Consequently, when we hear “We have a long way to go until our campaign fund drive is finished,” we understand ourselves metaphorically as moving along a path toward the destination (completion of the fund drive), and we understand that there can be obstacles along the way that would slow our progress.

Conceptual metaphor theory proposes that all abstract conceptualization works via conceptual metaphor, conceptual metonymy, and a few other principles of imaginative extension. To date there is a rapidly growing body of metaphor analyses of key concepts in nearly every conceivable intellectual field and discipline, including the physical and biological sciences, economics, morality, politics, ethics, philosophy, anthropology, psychology, religion and more. For example, Lakoff and Nunez (2000) have carried out extensive analyses of the fundamental metaphorical concepts that underlie mathematics, from simple models of addition all the way up to concepts of the Cartesian plane, infinity, and differential equations. Winter (2001) analyzes several key metaphors that define central legal concepts and are the basis for legal reasoning. Grady (1997) examines “primary metaphors” (such as PURPOSES ARE DESTINATIONS) that are combined systematically into more complex metaphors (such as PURPOSEFUL ACTIVITIES ARE JOURNEYS).

The reason that conceptual metaphor is so important is that it is our primary means for abstract conceptualization and reasoning. Pragmatism’s principle of continuity claims that abstract thought is not disembodied; rather, it must arise from our sensorimotor capacities and is constrained by the nature of our bodies, brains, and environments. From an evolutionary perspective this means that we have *not* developed two separate logical and inferential systems, one for our bodily experiences and one for our abstract reasoning (as a pure logic). Instead, the logic of our bodily experience provides all the logic we need in order to perform every rational inference that we do. In our metaphor-based reasoning, the inferences are carried out via the corporeal logic of our sensorimotor capacities, and then, via the source-to-target domain mapping, the corresponding logical inferences are drawn in the target domain.

For example, there is definite spatial or bodily image-schematic logic of containment that arises in our experience with containers:

(a) An entity is either inside the container or outside it, but not both at once.
(b) If I place an object *O* within a physical container *C* and then put container *C* inside of another container *D,* then *O* is in *D*.

In other words, our bodily encounters with containers and objects that we observe and manipulate teach us the spatial logic of containers.

Next, consider the common conceptual metaphor CATEGORIES ARE CONTAINERS, in which a conceptual category is understood metaphorically as an abstract container for physical and abstract entities. For example, we may say that "the category 'human' is *contained in* the category 'animals,' which is *contained in* the category 'living things.'" Similarly, we may ask "Which category is this tree *in*?" Based on the inferential image-schematic structure of the source domain, and via the source-to-target mapping, we then have corresponding inferences about abstract concepts:

(a') An entity either falls within a given category, or falls outside it, but not both at once [e.g., Charles cannot be a man and not a man at the same time, in the same place, and in the same manner]. (The Law of the Excluded Middle).
(b') If an entity *E* is in one category *C'*, and *C'* is in another category *D'*, then that entity *E* is in category *D'* [For example, All men are mortal (*C'* is in *D'*) and Socrates is a man (*E* is in *C'*), therefore Socrates is mortal (*E* is in *D'*)].

Thus, according to CMT we would then predict that the abstract inferences are "computed" using sensorimotor neural maps, and those inferences are activated as target-domain inferences because there are neural connections from sensorimotor areas of the brain to other areas that are responsible for so-called "higher" cognitive functions. The hypothesis is that human beings don't run an inferential process at the sensorimotor level and then perform an entirely different inferential process for abstract concepts; rather, human beings utilize the inference patterns found in the sensorimotor brain regions to perform "abstract" reasoning. Just as the Pragmatist Principle of Continuity requires, there is no need to introduce a new kind of reasoning (with a different ontological basis) to explain logical reasoning with abstract concepts.

4.3 Evidence for conceptual metaphor and abstract reasoning using conceptual metaphors

Recently several new sources of evidence have become available to explain the possible neural bases for the image-schematic mappings that operate in conceptual metaphors. The new evidence comes from both the patient-based neurological literature and neuroimaging studies of normal adults. While we have long known that patients can develop anomias reflecting selective category deficits for animals, tools, and plants (Warrington and Shallice 1984), several recent studies have reported a selective category deficit for body-part terms (Suziki, Yamadori and Fujii 1997; Shelton, Fouch and Caramazza 1998; Coslett, Saffran and Schwoebel 2002; Schwoebel, Boronat and Coslett 2002). The deficit work suggests that lesions in the secondary motor cortices, in regions which likely contain both somatotopic and egocentric spatial maps, can cause difficulties in tasks such as body part naming, naming contiguous sections of the body, and so on. This finding suggests that the comprehension of body part terms requires the active participation of these neural maps.

Two other neuroimaging studies also show that we can drive the human somatomotor maps with both metaphoric and literal linguistic stimuli relating to the body. In a fMRI study, Hauk, Johnsrude and Pulvermuller (2004) have shown that single word terms such as “smile,” “punch” and “kick” differentially activate face, arm/hand, and leg regions within the somatomotor maps, suggesting that literal language can differentially activate *body-part related* somatomotor neural maps. Similarly, a fMRI neuroimaging study by Rohrer (2001b; 2005) shows that both literal and metaphoric sentences using hand terms (e.g. “She grasped the apple” and “He grasped the theory”) activate primary and secondary hand regions within the primary and secondary sensorimotor maps. After the presentation of the linguistic stimuli, Rohrer also mapped the hand somatic cortex of each study participant using a tactile hand stroking task. A comparison between the tactile and the sentential conditions shows a high degree of overlap in the primary and secondary somatomotor cortex for both language tasks (figure 1).

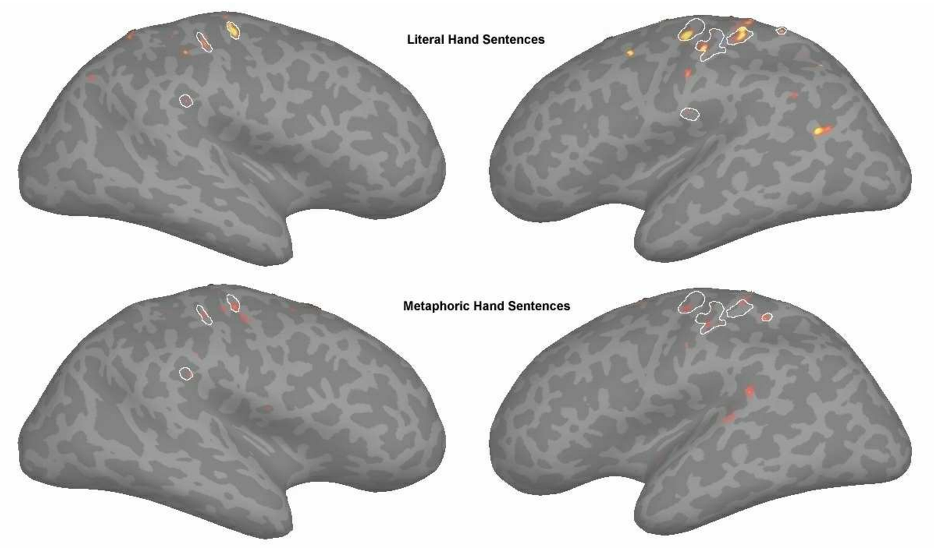

Figure 1 – fMRI activation courses in response to literal and metaphoric action sentences. Areas active and overlapping from a hand somatosensory task were outlined in white (Rohrer 2001b).

There is also evidence from neurocomputationally inspired models of conceptual metaphor and abstract reasoning. Building on Regier’s work on modelling the image-schematic character of spatial relation terms, Narayanan (1997; Feldman and Narayanan 2004) developed a constrained connectionist network to model how the bodily logic of our sensorimotor systems enables us to perform abstract reasoning about international economics using conceptual metaphors. For example, the system was able to successfully interpret both “In 1991, the Indian government deregulated the business sector” and “In 1991, the Indian government loosened its stranglehold on business.” Narayanan’s model can perform inferences either entirely within the sensorimotoric domain or in the linguistic domain using common conceptual metaphor mappings. Taken together with the neurophysiological and neuroimaging evidence for image schemas and conceptual metaphors, these neurocomputational models support the image-schematic and metaphoric basis of our language and abstract reasoning.

5. The Continuity of Embodied Social and Cultural Cognition

In this chapter, we have been presenting evidence for the embodied character of cognition, and we have suggested an appropriate Pragmatist philosophical framework for interpreting that evidence. Contra Representationalism, we have argued that cognition is not some inner process performed by the "mind," but rather is a form of embodied action. We argued this by giving examples of how cognition is located in organism-environment interactions, instead of being locked up in some allegedly private mental sphere of thought. However, an exclusive focus on the organism's engagement and coupling with its environment can lead to the mistaken impression that thought is individual, not social. Therefore, we must at least briefly address the crucial fact that language and abstract reasoning are socially and culturally situated activities.

Thus far, we have discussed only one socio-cultural dimension, albeit a crucially important one, namely, development. Our brief discussion of development was framed more within the context of nervous systems than within socio-cultural interactions. We stressed the point that epigenetic bodily interactions with the world are what shape our neural maps and the image schemas in them. For humans, a very large and distinctive part of that involves interacting with other humans. In other words, human understanding and thinking is social. This raises the question: How do socially and culturally determined factors come to play a role in human cognition?

Perhaps a sceptic might say that the locus of the distinctively human lies in a socially and culturally learned capacity for classical Representationalism. Once again, however, the Representationalist proposal rests on two mistakes. First, there is not a radical ontological break from the rest of the animal kingdom with respect to socially and culturally transmitted behaviors, both in general and specifically in the cases of linguistic and symbolic communication. Second, having challenged the "inner mind" versus "outer body" split, we must not then proceed to replace it with another equally problematic dichotomy—that between the "individual" and the "social." We must recognize that cognition does not take place only within the brain and body of a single individual, but instead is partly constituted by social interactions and relations. The evidence to which we now turn comes from cognitive ethology and distributed cognition. Of course there are ways in which our socio-cultural behaviors are peculiarly human, but the story is once again much more complex and multi-dimensional than classical Representationalists suppose.

Following Maturana and Varela (1998: 180-184) we would define social phenomena as those phenomena arising out of recurrent structural couplings that require the co-ordinated participation of multiple organisms. They argue that just as the cell-to-cell interactions in the transition from single to multi-cellular organisms afford a new level of *intercellular* structural coupling, so also recurrent interactions between organisms afford a new level of *inter-organism* structural coupling.

The social insects are perhaps the most basic example of this kind of recurrent inter-organism behaviors. For example, ants must feed their queen for their colony to remain alive. Individual workers navigate their way to and from the nest and food sources by leaving trails of chemical markers, but these markers are not distinctive to the individual ant. When seeking food, an individual ant moves away from markers dropped by other ants. Naturally the density of such markers decreases in proportion to the distance from the nest. But when one finds food they begin to actively seek denser clusters of markers, thus leading them back to the nest. Furthermore, whenever a worker ant eats, their chemical markers change slightly. These chemical markers attract, rather than repel, other ants. Thus the ants gradually begin to form a column leading from a food source to a nest. Note that the ants' cognition is both social, in that it takes place between organisms, and distributed, in the sense that it offloads much of the cognitive work onto the environment. No single ant carries around an "internal representation" or neural map of where the ant colony is. Ant cognition is thus nonrepresentational in that it is both intrinsically social and situated in organism-environment interactions.

The evolutionarily programmed social cognition of insects, however, does not include the capacity for spontaneous imitation which is so central to human cognition. For a social behavior to become a learned behavior and then continue across generations, a capacity for spontaneous imitation is crucial. However, zoological ethologists have long known that this imitative capacity is not unique to humans. Researchers studying macaques left sweet potatoes on the beach for a colony of wild monkeys who normally inhabit the jungle near the beach. After gradually becoming habituated to the beach and becoming more familiar with the sea, one monkey discovered that dipping the potatoes in a tidepool would cleanse them of the sand that made them unpalatable. This behavior was imitated throughout the colony in a matter of days, but the researchers observed that older macaques were slower to acquire the behavior than the younger ones (Kawamura 1959; McGrew 1998). Maturana and Varela (1998: 203) define cultural behavior precisely as this kind of relatively stable pattern of such transgenerational social behavior.

The culturally acquired behavior most often held up by classical Representationalists as the hallmark of the distinctively human is language. However, even here there is not a clear break from the animal kingdom in terms of basic cognitive capabilities, as we see when considering the results of researchers who have been trying to teach symbolic communication to other primates. Instead, their observations are consonant with our theory of how language and image schemas emerge from bodily processes involving cross-modal perception. In experiments done by Savage-Rumbaugh and colleagues (1988), three chimpanzees who had been trained in symbolic communication were able to make not only cross-modal associations (i.e. visual to tactile), but were able to make symbolic to sensory-modal associations. For example, Kanzi was able to hear a spoken English word and accurately (100% of the time) choose either the corresponding visual lexigram or a visual picture of the word. Sherman and Austin were able to choose the appropriate object by touch when presented with a visual lexigram (100% correct), and conversely they were also able to choose the appropriate visual lexigram when presented with a tactile-only stimulus (Sherman: 96% correct, Austin: 100%) or olfactory-only stimulus (Sherman: 95% correct, Austin 70%: correct). Their ability to perform such symbol to sensory-modality coordination enhanced their performance on tasks measuring solely cross-modal coordination; as Savage-Rumbaugh et al. observe: "these symbol-sophisticated apes were able to perform a variety of cross-modal tasks and to switch easily from one type of task to another. Other apes have been limited to a single cross-modal task" (1988: 623). Although these chimpanzees will never approach the linguistic capabilities of humans, these results show that the continuity of our human capacity for abstract cross-modal thought is shared by at least some members of the animal kingdom.[5]

In fact, related recent research on primates suggests that it is the distinctively human socio-cultural environment (and not some great zoological discontinuity in comparative cognitive capacity) that facilitates the cross-modal cognitive capabilities underlying language and abstract reason. We have already noted the neural development of the cross-modal maps of juvenile owls can be modified by epigenetic stimulation, but it is equally important to realize that the cross-modal basis for many of our image schemas require epigenetic stimulation of the kind presented by human parents. Tomasello, Savage-Rumbaugh and Kruger (1993) compared the abilities of chimpanzees and human children to imitatively learn how to perform novel actions with novel objects. They tested 3 conspecific (mother-reared) chimpanzees and 3 enculturated chimpanzees, along with 18 and 30 month-old human children. They introduced a new object into the participant's environment, and after observing the participant's natural interactions with the object, the experimenter demonstrated a novel action with the object with the instruction "Do what I do." Their results showed that the mother-reared chimpanzees were much poorer imitators than the enculturated chimpanzees and the human children, who did not differ from one another. A human-like sociocultural environment is an essential component not only for the development of our capacity for imitation, but also for the development of our capacities for the cross-modal image schemas that underlie language and abstract reasoning (see also Fouts, Jensvold & Fouts 2002).

Finally, there is also considerable evidence from cognitive anthropology that adult humans do not think in a manner consistent with the dichotomies posed by classical Representationalism. Like the social insects, we tend to offload much of our cognition onto the environments we create. We tend to accomplish this in two ways—first, we make cognitive artifacts to help us engage in complex cognitive actions, and, second, we distribute cognition among members of a social organization. As an example of the first, Hutchins (1995: 99-102) discusses how medieval mariners used the 32-point compass rose to predict tides. By superimposing onto the compass rose the 24-hour day (in 45-minute intervals), the mariners could map the lunar "time" of the high tide (the bearing of the full moon when its pull causes a high tide) to a solar time of day. As long as we know two facts—the number of days since the last full moon and the lunar high tide for a particular port—we simply count off a number of points on the compass rose equal to the days past the full moon to compute the time of next high tide. Without the schema provided by the cognitive artifact, computing the next high tide is a much more laborious cognitive task. As an example of the second, Hutchins (1995: 263-285) discusses how the partially overlapping knowledge distributions of a group of three navy navigation personnel function cognitively within the team considered as a team. Although no single team member is expected to constantly maintain a complete internal representation of all the navigational data, Hutchins shows how the social distribution of the cognitive tasks functions as a brake on serious navigational errors that could imperil the ship, because the participants each know some of the spatial relations and procedures immanent to another team member's job. In short, the offloading of some of the cognitive load onto the environment, as found both in cognitive artifacts and the social distribution of cognitive tasks, is crucial to many of our daily cognitive activities.

---

[5] This conclusion is further supported by results showing that human children with specific language impairments show deficiencies in their ability to perform cross-modal tasks (Montgomery 1993).

A fully adequate treatment of the social dimension of thought would require substantially more evidence and analysis than we can provide here. We have only attempted to suggest that sociocultural cognition in general is not unique to humankind, that the common bases for cross-modal cognition and symbolic/linguistic communication are not unique to humans, and that human cognition cannot be locked up within the private workings of an individual mind. Since thought is a form of co-ordinated action, it is spread out in the world, co-ordinated with both the physical environment and the social, cultural, moral, political, and religious environments, institutions, and shared practices. Language—and all forms of symbolic expression—are quintessentially social behaviors. Dewey nicely summarizes the intrinsically social character of all thought in his argument that the very idea of thinking as a kind of inner mental dialogue is only possible because of socially established and preserved meanings, values, and practices:

> When this introspectionist thinks he has withdrawn into a wholly private realm of events disparate in kind from other events, made out of mental stuff, he is only turning his attention to his own soliloquy. And soliloquy is the product and reflex of converse with others; social communication not an effect of soliloquy. If we had not talked with others and they with us, we should never talk to and with ourselves. Because of converse, social give and take, various organic attitudes become an assemblage of persons engaged in converse, conferring with one another, exchanging distinctive experiences ... Through speech a person dramatically identifies himself with potential acts and deeds; he plays many roles, not in successive stages of life but in a contemporaneously enacted drama. Thus mind emerges (Dewey 1925: 135).

“Thus mind emerges!” It emerges as, and is enacted through, social cognition. There is no radical rupture with our bodily experience of meaning; instead, that meaning is carried forward and given voice through language and other forms of social symbolic interaction and expression.

6. Embodied Meaning, Thought, and Language

We have been arguing against disembodied views of mind, concepts, and reasoning, especially as they underlie Representationalist theories of mind and language. Our alternative view—that cognition is embodied—has roots in American Pragmatist philosophy and is being supported and extended by recent work in second-generation cognitive science. Pragmatists like James and Dewey understood that philosophy and empirical science must develop in mutual cooperation and criticism, if we are ever to have an empirically responsible understanding of the human mind and all of its marvelous capacities and acts. Pragmatism is characterized by (1) a profound respect for the richness, depth, and complexity of human experience and cognition, (2) an evolutionary perspective that appreciates the role of dynamic change in all development (as opposed to fixity and finality), and (3) recognition that human cognition and creativity arise in response to problematic situations that involve values, interests, and social interaction. The *principle of continuity* encompasses the fact that apparently novel aspects of thought and social interaction arise naturally via increased complexity of the organism-environment interactions that constitute experience. Pragmatists thus argue that all of our traditional metaphysical and epistemological dualisms (e.g., mind/body, inner/outer, subject/object, concept/percept, reason/emotion, knowledge/imagination, and theory/practice) are merely abstractions from the interactive (enactive) process that is experience. Such distinctions are not absolute ontological dichotomies. Sometimes they serve us well, but oftentimes they serve us quite poorly, depending on what problems we are investigating, what values we have, and what the socio-cultural context is.

In recent years the number of researchers engaged in some variation of "embodied cognition" has swelled prodigiously. Once upon a time, cognitive science seemed defined by the Representationalist view that the body is inconsequential to the study of the mind. But that has changed dramatically. Some Representationalists have recently argued for a very limited sense of embodiment that would keep intact much of the first generation of cognitive science's representational baggage (Clark 1997). Today we are witnessing a new generation of cognitive science emerging which defines "embodied cognition" as a fundamentally non-representational project. Contributions to a radical theory of embodied cognition are being made by dynamic systems theorists who argue that cognition, though amenable to mathematical description, is not computational (Van Gelder 1995), by neurobiologists whose experiments show us how metaphors of information transfer mislead us in understanding the population dynamics behind neural organization (Edelman 1992), and by cognitive roboticists who understand that having a body is perhaps not such a bad thing after all (Brooks 1991; Brooks and Stein 1994). Even Alan Turing, a leader among that lost first generation who so errantly steered cognitive science toward disembodiment, was willing to admit he might be wrong when it came to how we might teach a robot language:

> It can also be maintained that it is best to provide the machine with the best sense organs that money can buy, and then teach it to understand and speak English. That process could follow the normal teaching of a child. Things would be pointed out and named, etc. Again, I do not know what the right answer is, but I think both approaches should be tried (Turing 1950: 460).

We have already tried the disembodied Representationalist approach, and its failures have breathed new life into the Pragmatist approach to embodied cognition.

The themes we have been tracing throughout this chapter—our animal engagement and cognition, our ongoing coupling and our falling in and out of harmony with our surroundings, our active value-laden inquiry to re-establish harmony and growth, and our community of social interactions—are beautifully encapsulated by Dewey in his attempt to recover the value of the aesthetic dimensions of meaning in human life:

> At every moment, the living creature is exposed to dangers from its surroundings, and at every moment, it must draw upon something in its surroundings to satisfy its needs. The career and destiny of a living thing are bound up with its interchanges with environment, not externally but in the most intimate needs.
>
> The growl of a dog crouching over his food, his howl in time of loss and loneliness, the wagging of his tail at the return of his human friend are expressions of the implication of a living in a natural medium which includes man along with the animal he has domesticated. Every need, say for hunger for fresh air or food, is a lack that denoted at least a temporary absence of adequate adjustment with surroundings. But it is also a demand, a reaching out into the environment by building at least a temporary equilibrium. Life itself consists of phases in which the organism falls out of step with the march of surrounding things and then recovers unison with it—either through effort or some happy chance…
>
> These biological commonplaces are something more than that [mere biological consequences]; they reach to the roots of the esthetic in experience (Dewey 1934: 535).

We humans are live creatures. We are acting when we think, perhaps falling in and out of step with the environment, but never are our thoughts outside of it. Via our bodily senses the environment enters into the very shape of our thought, sculpting our most abstract reasoning from our embodied interactions with the world.

--mj & tr

References

Anderson, Michael
2003 Embodied Cognition: A field guide. *Artificial Intelligence* 149: 91-130.
Brooks, Rodney A.
1991 Intelligence Without Representation. *Artificial Intelligence Journal* 47: 139–159.
Brooks, Rodney A. and Anita M. Flynn
1989 Fast, Cheap and Out of Control: A Robot Invasion of the Solar System. *Journal of the British Interplanetary Society*, 42: 478–485.
Brooks, Rodney. A. and Lynn A. Stein
1994 Building Brains for Bodies. *Autonomous Robots* 1(1): 7–25.
Buccino, Giorgio, F. Binkofski, Gereon R. Fink, Luciano Fadiga, Leonardo Fogassi, Vittorio Gallese, Rüdiger J. Seitz, Karl Zilles, Giacomo Rizzolatti and Hans-Joachim Freund
2001 Action observation activates premotor and parietal areas in a somatotopic manner: an fMRI study. *Eur J Neurosci.* (2):400-4.
Buonomano, Dean V. and Michael M. Merzenich
1998 Cortical plasticity: from synapses to maps. *Annu Rev Neurosci.* 21:149-86.
Clark, Andy
1998 *Being There: Putting Brain, Body, and World Together Again*. Cambridge, MA: MIT Press.
Coslett, H. Branch, Eleanor M. Saffran and John Schwoebel
2002 Knowledge of the human body: a distinct semantic domain. *Neurology* 59, 357-63.
DeBello, William M., Daniel E. Feldman and Eric I. Knudsen
2001 Adaptive axonal remodeling in the midbrain auditory space map. *J Neurosci*. 21(9):3161-74.
Deneubourg, Jean-Louis, Jacque Marie Pasteels, and Jean-Claude Verhaeghe
1983 Probabilistic Behavior in Ants: A Strategy of Errors. *Journal of Theoretical Biology* 105: 259-271.
Dewey, John
1925 *Experience and Nature.* In: *John Dewey, The Later Works, 1925-1953,* vol. 1, Jo Ann Boydston (ed.). Carbondale: Southern Illinois University Press, 1981.
1934 *Art as Experience.* New York: Penguin-Putnam Inc., reprinted 1980.
1938 *Logic: The Theory of Inquiry*, In: *John Dewey, The Later Works, 1925-1953,* vol. 12, Jo Ann Boydston (ed.). Carbondale: Southern Illinois University Press, 1981.
Edelman, Gerald
1987 *Neural Darwinism*. New York: Basic Books.
1992 *Bright Air, Brilliant Fire: On the Matter of Mind.* New York: Basic Books.
Erickson, Harold P., Dianne W. Taylor, Kenneth A. Taylor and David Bramhill
1996 Bacterial cell division protein FtsZ assembles into protofilament sheets and minirings, structural homologs of tubulin polymers. *Proc Natl Acad Sci U S A.* 93(1): 519-23.
Feldman, Jerome and Srini Narayanan
2004 Embodied meaning in a neural theory of language. *Brain and Language* 89(2): 385-92.
Fodor, Jerry
1987 *Psychosemantics: The Problem of Meaning in the Philosophy of Mind.* Cambridge, MA: MIT Press.
Fogassi, Leonardo, Vittorio Gallese, Giorgio Buccino, Laila Craighero, Luciano Fadiga and Giacomo Rizzolatti
2001 Cortical mechanism for the visual guidance of hand grasping movements in the monkey: A reversible inactivation study. *Brain* 124(3): 571-86.
Fouts, Roger S., Jensvold, Mary Lee A. & Fouts, Deborah H.
2002 Chimpanzee signing: Darwinian realities and Cartesian delusions. In: Marc Bekoff, Colin Allen & Gordon M. Burghardt (eds.) *The cognitive animal: Empirical and theoretical perspectives in animal cognition*. Cambridge, MA: MIT Press, 285-291.
Fraser, Scott E.
1985 Cell interaction involved in neural patterning: An experimental and theoretical approach. In: Gerald Edelman, W.E. Gall and W. M. Cowan (eds.) *Molecular Bases of Neural Development*, 581-507. New York: Wiley.

Gallese, Vittorio and George Lakoff
2005 The Brain's Concepts: The Role of the Sensory-Motor System in Reason and Language. *Cognitive Neuropsychology* 22: 455 - 479.
Gaze, R.M. and Sansar C. Sharma
1970 Axial differences in the reenervation of the goldfish optic tectum by regenerating optic nerve fibers. *Experimental Brain Research,* 10: 171-81.
Goldberg, Jeffrey L.
2003 How does an axon grow? *Genes Dev.* 17(8): 941-58.
Grady, Joseph
1997 Foundations of meaning: primary metaphors and primary scenes. University of California, Berkeley: Ph.D. Dissertation.
Guo, Yajin and Susan B. Udin
2000 The development of abnormal axon trajectories after rotation of one eye in Xenopus. *J Neurosci*. 20(11): 4189-97.
Hauk, Olaf , Ingrid Johnsrude and Friedemann Pulvermüller
2004 Somatotopic representation of action words in human motor and premotor cortex. *Neuron* 41(2):301-7.
Hodges, Andrew
1983 *Alan Turing: The Enigma*. New York: Walker and Co.
Hutchins, Edwin
1995 *Cognition in the Wild*. Cambridge, MA: MIT Press.
James, William
1900 *Psychology (American Science Series, Briefer Course),* New York: Henry Holt and Company.
Johnson, Mark
1987 *The Body in the Mind: The Bodily Basis of Meaning, Imagination and Reason.* Chicago: University of Chicago Press.
Kawamura, Syunzo
1959 The process of subculture propagation among Japanese macaques. *Primates* 2: 43-60.
Knudsen, Eric I.
2002 Instructed learning in the auditory localization pathway of the barn owl. *Nature*. 417(6886):322-8.
1998 Capacity for plasticity in the adult owl auditory system expanded by juvenile experience. *Science* 279(5356): 1531-3.
Lakoff, George
1987 *Women, Fire and Dangerous Things*. Chicago: University of Chicago Press.
Lakoff, George and Mark Johnson
1980 *Metaphors We Live By*. Chicago: University of Chicago Press.
1999 *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought.* New York: Basic Books.
Lakoff, George and Rafael Núñez
2000 *Where Mathematics Comes From: How the Embodied Mind Brings Mathematics Into Being.* New York: Basic Books.
Langacker, Ronald
1986 *Foundations of Cognitive Grammar.* 2 vols. Stanford: Stanford University Press
Lewkowicz, David J. and Gerald Turkewitz
1981 Intersensory interaction in newborns: modification of visual preferences following exposure to sound. *Child Development* 52(3): 827-32.
Maturana, Humberto R. and Francisco J. Varela
1998 *The Tree of Knowledge: The Biological Roots of Human Understanding, revised edition.* (Robert Paolucci, trans. 1987 *Arbol del conocimiento.*) Boston: Shambhala Press.
McGrew, William C.
1998 Culture in Nonhuman Primates? *Annual Review of Anthropology* 27: 301-28.
Meltzoff , Andrew N. and Richard W. Borton
1979 Intermodal matching by human neonates. *Nature* 282(5737):403-4.

Merzenich, Michael M., Randall J. Nelson, Jon H. Kaas, Michael P. Stryker, Max S. Cynader, A. Schoppmann and John M. Zook

1987 Variability in hand surface representations in areas 3b and 1 in adult owl and squirrel monkeys. *J Comp Neurol.* 258(2):281-96.

Montgomery, James W.

1993 Haptic recognition of children with specific language impairment: effects of response modality. *J Speech Hear Res.* 36(1): 98-104.

Narayanan, Srini

1997 KARMA: Knowledge-based active representations for metaphor and aspect. Ph.D. dissertation, University of California at Berkeley.

Newell, Alan and Herbert Simon

1976 Computer science as empirical inquiry: Symbols and search. *Communications of the ACM* 19: 113–126.

Regier, Terry

1996 *The Human Semantic Potential Spatial Language and Constrained Connectionism.* Cambridge, Mass.: MIT Press.

Rizzolatti, Giacomo, Leonardo Fogassi and Vittorio Gallese

2002 Motor and cognitive functions of the ventral premotor cortex. *Curr Opin Neurobiol.* 12(2): 149-54.

Rohrer, Tim

2001a Pragmatism, Ideology and Embodiment: William James and the philosophical foundations of cognitive linguistics. In *Language and Ideology: Cognitive Theoretic Approaches: volume 1.* René Dirven, Bruce Hawkins and Esra Sandikcioglu, eds., Amsterdam: John Benjamins, 2001, pp. 49-81.

2001b Understanding through the Body: fMRI and of ERP studies of metaphoric and literal language. Paper presented at the *7th International Cognitive Linguistics Association* conference, July 2001.

2005 Image Schemata in the Brain. In: *From Perception to Meaning: Image Schemas in Cognitive Linguistics,* 165-196. Hampe, Beate and J. Grady (eds.) Berlin: Mouton de Gruyter.

In press Embodiment and Experientialism. In: *Handbook of Cognitive Linguistics*. Geeraerts, Dirk and Cuyckens, Hubert, (eds). New York: Oxford University Press.

Savage-Rumbaugh, Sue, Rose A. Sevcik and William D. Hopkins

1988 Symbolic cross-modal transfer in two species of chimpanzees. *Child Development* 59(3): 617-25.

Schwoebel, John, Consuelo B. Boronat and H. Branch Coslett

2002 The man who executed ‘imagined’ movements: evidence for dissociable components of the body schema. *Brain Cogn* 50(1):1-16.

Shelton, Jennifer R., Erin Fouch and Alfonso Caramazza

1998 The selective sparing of body part knowledge. A case study. *Neurocase* 4: 339-351.

Sperry , Roger W.

1943 Effect of a 180-degree rotation of the retinal field on visuomotor coordination. *Journal of Experimental Zoology* 92: 263-79.

Stern, Daniel

1985 *The Interpersonal World of the Infant.* New York: Basic Books.

Stern, Daniel, L. Hofer, W. Haft and J. Dore

1987 Affective attunement: division of emotional states between mother and child by cross-modal exchange [In French]. *Ann Med Psychol (Paris).* Mar;145(3):205-24.

Suziki, K., A. Yamadori and T. Fujii

1997 Category specific comprehension deficit restricted to body parts. *Neurocase* 3: 193-200.

Talmy, Leonard

1985 Force Dynamics in Thought and Language. *Chicago Linguistics Society 21, Pt 2: Possession in Causatives and Agentivity,* 293-337.

Tomasello, Michael, Sue Savage-Rumbaugh, and A.C. Kruger

1993 Imitative learning of actions on objects by children, chimpanzees, and enculturated chimpanzees. *Child Development* 64(6): 1688-705.

Turing, Alan M.

1937 On Computable Numbers, with an Application to the Entscheidungsproblem. *Proceedings of London Mathematical Society, Series 2*, 42: 230-265

1950 Computing Machinery and Intelligence. *Mind*, 59(236): 433-460.

van Gelder, Tim

1995 What Might Cognition Be, If Not Computation? *Journal of Philosophy* 92(7): 345-381.

Varela, Francisco, Evan Thompson and Eleanor Rosch

1991 *The Embodied Mind: Cognitive Science and Human Experience.* Cambridge: MIT Press.

Warrington, Elizabeth K. and Tim Shallice

1984 Category Specific semantic impairments. *Brain* 107: 859-854.

Winter, Steven

2001 *A Clearing in the Forest: Law, Life, and Mind.* Chicago: University of Chicago Press.

Ziemke, Tom. 2003. What's that thing called embodiment? *Proceedings of the 25th Annual Meeting of the Cognitive Science Society*. 1305-1310. Lawerence Erlbaum. http://www.ida.his.se/~tom/cogsci03.pdf [10.14.03]