SEMIOTICA

JOURNAL OF THE INTERNATIONAL ASSOCIATION FOR SEMIOTIC STUDIES

REVUE DE L'ASSOCIATION INTERNATIONALE DE SÉMIOTIQUE

Editor-in-Chief/Rédacteur en Chef
THOMAS A. SEBEOK

Offprint/Tiré à part

Mouton de Gruyter
Berlin · New York

Epistemic ordering and the development of space-time: Intentionality as a universal entailment

ROD SWENSON

Introduction and background

The epistemic dimension of the world distinguishes itself by end-directed behavior dependent on meaning, and since the program of biosemiotics can be taken as an effort to develop a naturalized evolutionary account of signification or meaning (e.g., Hoffmeyer 1996a, 1996b, 1997, in press), biosemiotics more generally construed can be taken as an effort to provide a principled or naturalized account of the epistemic dimension. The challenge remains because modern science, its many accomplishments aside, built its foundations on Cartesian metaphysical assumptions that incommensurably separate the epistemic dimension from the rest of the world (e.g., psychology from physics, 'mind' from 'matter', knower from known, or self from other, and later biology from physics, or living things from their environments). Physics and psychology, to underscore the point, were literally defined at their modern origins by their mutual exlcusivity (Swenson and Turvey 1991). This bifurcated world view found its way into biology through Kant, and became fully entrenched with Boltzmann's hypothesis of the second law of thermodynamics (the 'entropy law') and the rise of Darwinian evolutionary theory which came to be built upon it. The world was seen as consisting of two incommensurable 'rivers', the river of physics, comprised of meaningless particles, flowing down to disorder, and the river of biology and psychology, characterized by active, end-directed, epistemic ordering, opportunistically 'flowing up' to increasingly higher states of order (Swenson 1997a). The universal laws of physics seemed to mandate a world of increasing disorder while the epistemic dimension of the world, that part encompassed by psychology and biology, was, on the other hand, in the order production business.

The single most pressing problem, in a word, is the problem of 'intentionality', what it is to the world, and what the basis for its epistemic or semantic content is. Sayre (1986) has recognized this as the most fundamental problem for cognitive science today, but it is the same

Semiotica 127–1/4 (1999), 567–597

0037–1998/99/0127–0567

problem that sits at the core of every other discourse by whatever name that deals with, or depends on, the epistemic dimension (e.g., psychology, philosophy of mind, action theory, the social sciences in general, theories of culture, and a basic understanding of life itself). There are two main components to the discourse on intentionality, growing largely, in modern times, out of the work of Brentano (1973 [1894]), and these are the idea of active directedness towards, and the idea that this directedness towards be distinguished or determined by semantic content ('aboutness'). The fundamental challenge of intentionality is thus to provide a principled account of active, end-directed behavior, or ordering of the world distinguished or determined by semantic content. Without such an account, theories of meaning, knowledge, or of things that know, of epistemic or cognitive processes in general, are themselves ungrounded and in a deep, and certainly ironic sense, inherently meaningless or, at best, ad hoc. The bottom quite literally falls out from under the ground of modern science on this issue since every human discourse (including physics, for example) is itself an instantiation of the epistemic dimension, and characterized therefore by intentionality. Modern science finds itself plagued with the 'Problem of Parmenides', the pre-Socratic who, it may be recalled, had a fully coherent theory of the world which, however, could neither account for, nor even accommodate his own epistemic existence (Swenson 1997a) (see furthur discussion below).

It is still a widespread view that 'meaning always involves human intentionality [and] intentionality is primarily a property of mental states' (Johnson 1987: 181), but while it is clear that meaning always involves intentionality, the assertion that it always involves *human* intentionality, or that intentionality is a property exclusive to human mental states, is an untenable position carried over directly from Cartesian postulates. If the world excluding human 'minds' is itself entirely meaningless, and intentionality is confined to mental states, then there is no way human minds can have semantic relations with the world. Indeed, this may be seen as the most general problem with Cartesian theories of perception ('indirect perception'), where perception is taken to be of or about mental states, and 'mind', as a consequence, is left perceiving itself with no principled way in or out (the 'Cartesian circle'). The idea that perception is basically an inferential process involving mental representations and the idea that intentional content is supplied to the world by such representations (or symbols) has been the basis for the computational view of mind that has dominated cognitive science in recent years. As Putnam (1980), for example, has shown, however, syntactical or rule-based systems cannot, for simple formal reasons alone, be the source of intentionality or semantic content, a fact even readily admitted by leading proponents of the computational or algorithmic view (e.g., Fodor's [1980] 'methodological solipsism'). In recent years the computational view has come under devastating attack both for formal reasons of this kind as well as by now obvious empirical ones (e.g., Johnson 1987; Juarrero in press; Lakoff 1987; MacKay 1986; Sayre 1986; Swenson 1997a; Thelen 1995; Turvey et al. 1981; Turvey and Shaw 1995; van Gelder and Port 1995).

Beyond this, the view that intentionality is confined to human mental states seeks to fly in the face of the seemingly undeniable empirical fact that life itself and its evolution is an epistemic process on which the intentionality of humans is parasitic (e.g., Callebaut and Pinxton 1987; Campbell 1987; Hoffmeyer 1996a; Matsuno 1989; Munz 1985; Radnitżky and Bartley 1987; Swenson 1988, 1989b, 1997a; Swenson and Turvey 1991). It is the epistemic relations between living things and their environments, or the 'intentional dynamics' of living things, to use Shaw's felicitous term (e.g., Shaw et al. 1992), defined here as 'end-directed behavior prospectively controlled or determined by meaning or "information about" ' (Swenson 1997a: 3), that effectively distinguishes the dynamics of the living in the most general sense from non-living. The emphasis is on relations between living things and their environments because it is through these relations that intentionality comes to be constituted and in the context of which semantic content is found. It is the 'organism-environment interface', as Hoffmeyer (in press) has put it, that must 'be placed at the center of evolutionary theory' if the epistemic dimension is to be understood, and it is just this interface, 'the interface between physics, psychology, and biology' (Swenson 1997a: 3), that the Cartesian postulates of incommensurability (the first between psychology and physics and the second between biology and physics) preclude from being understood. A principled account of intentionality, a theory that can show what it is, in effect, to the world, and provide the basis for semantic content or meaning, must be an account that can dissolve these postulates.[1] It is the main points of such an account that I will put forward in the remainder of this article. Something is entailed by another thing if, given the latter, the former is necessary as an accompaniment. Universal entailment is distinguished from simple (or logical) entailment by virtue of being necessary as a consequence of universal or natural law.

The Cartesian worldview, closed-circle theory, and evolutionary epistemology: *Cogito ergo sum*, and the 'Cartesian circle'

While for Aristotle the world was seen as inherently active and end-directed, with the study of ends, or the telos of things seen as the most fundamental kind of inquiry, with the rise of modern science causal explanation was reduced to efficient cause (the local, side-side, or billiard ball-like interaction of things), and end-directedness completely removed from the physical world. Although it was Newtonian mechanics that ultimately gained the greatest success, it was the dualist metaphysics of Descartes that provided the ground on which Newtonian physics and the later disciplines of modern science came to flourish. It was Descartes who literally defined psychology and physics at their modern origins by their mutual exclusivity (call this the 'first postulate of incommensurability' [Swenson 1997b]). The physical part of the world, or 'dead' purposeless 'matter', was said to be exhaustively defined by extension in space and time, and consist of reversible, qualityless, inert particles governed by efficient cause and rigid deterministic law from which the striving immaterial 'mind' ('thinking I', Cartesian self, or psychological part), seen as boundless, or without spatial and temporal dimension, was taken to be immune. The epistemic dimension of the world, in effect, was literally defined right out of the physical world.

Descartes justified his radical separation of the physical and epistemic parts of the world with his theory of perception, his consequent retreat to subjectivism and his famous *cogito ergo sum* ('I think, therefore I am'). What is indubitably 'given', he said, is the independent 'thinking I', self, or 'mind', in effect, perceiving itself. Since the hypothesized physical world was defined exhaustively by extension (and thus inherently meaningless or without intension), perception, by definition intentional (characterized by 'aboutness'), had to be of mental states ('indirect perception'). On these grounds, the epistemic dimension of the world became, in effect, a closed circle (a 'Cartesian circle') with no principled way in or out; no rational basis for justifying belief in what was taken as an external, outside, or objective world (the 'other'). The only real ground for believing in an external world, according to Descartes, was the fact that God, being perfect, and thus incapable of deception, would not have us believe in it if it did not exist. The insoluble problem of dualist interactionism further challenged the theory since two parts defined by their mutual exclusivity cannot *ex hypothesi* interact without violating the dualism (e.g., 'mind' cannot take on the property of 'matter' without losing the properties that, from this view, distinguish it as mind). Leibniz recognized the empirical manifestation of this problem by anticipating the conservation of energy (the first law of thermodynamics) (see Swenson 1997a, in press a).

Closed-circle theory and the social psychology of knowledge production

Post-Cartesian theories of knowledge, intentionality, and meaning tend to be aligned with social psychological (more broadly, cultural), or evolutionary accounts, interestingly as competing paradigms (Munz 1985). The later Wittgenstein, and Kuhn are exemplars of the first ('closed-circle theorists'), and Popper, Lorenz, and Campbell are exemplars of the second ('evolutionary epistemologists') (Munz 1985; Swenson 1997a and 1997b). Rather than hiding from incommensurability, and the relativism or anti-realism it engenders, closed-circle theorists have worn it proudly, in some cases, as a badge of enlightenment or epistemological sophistication. Various forms of constructivism, and also what is sometimes referred to as 'second-order cybernetics', are all kinds of closed-circle theory which can be understood, in general, as a transposition of the Cartesian circle from the individual to the social psychological or cultural level. The computational view of mind which has dominated cognitive science in recent years (e.g., Fodor 1980), which places meaning and intentionality in symbols or mental representations in individual 'minds' qua computational devices is a mechanized version of the Cartesian circle. In this and the next subsection the core assertions and problems associated with closed-circle theory and evolutionary epistemology are reviewed in abbreviated form (more detailed discussion can be found in Swenson 1997a, 1997c, in press a).

The idea of cultural systems decontextualized from their environments acting *sui generis* as closed-circles with the parts all functioning to maintain the whole is strongly expressed in the work of Malinowski (it is found in the early work of Spencer and others, but not in the decontextualized sense, e.g., see Swenson 1990). The full-blown transposition of the Cartesian circle to the cultural level is found in the work of the later Wittgenstein (Munz 1985; Swenson 1997a, in press a). Whereas meaning and intentionality for Descartes come into the world as properties of mental states internal to the closed-circular relations of the human mind, for Wittgenstein they come into the world internal to the closed intersubjective circular relations of human cultural systems — in 'language games' consisting of sets of rules that make up closed-circles of meanings. There are no individual meanings, for Wittgenstein, because there are no personal languages, and just as there is no principled way in or out of the Cartesian circle there can be no ostensive pointing or reference to anything outside the language game to an objective world or external context because all meaning is a property of the rules internal to the game. In addition, because meaning is thus entirely relative to the rules of each system, truth can only be measured with respect to the rules, or authority, of a particular community. There is no meaning invariance, or 'truth', across systems, and such circles are thus incommensurable or incomparable with respect to each other.

Close-circle language games are recycled in Kuhn's influential philosophy of science where they are repackaged as 'paradigms' (Munz 1985). The formal relations, or 'systems logic', are isomorphic; thus because paradigms, like Wittgenstein's language games, are closed circles of meaning without meaning invariance between them, they are also incommensurable with respect to each other. Due to the incommensurability of paradigms, no paradigm can be 'truer' than another and there is thus no basis to compare them or ground to establish a direction in time, and the succession of paradigms in this view is therefore time-symmetric, and progress, or a direction to the development of science or in the general production of knowledge, is thus denied (e.g., Einstein's theory could have preceded Newton's; the theory of oxygen could have preceded the theory of phlogiston; the theory of heat and the conservation of energy could have preceded that of the caloric). The radical relativism of closed-circle theory carries forward the anti-realism of positivism, but challenges its rationality as well. Closed-circle theory has been seen by its proponents as a kind of enlightened alternative to modernism, but it is itself modernism carried to a certain post-Humean, post-Kantian extreme conclusion. The Cartesian core is still there only now transposed from the individual to cultural level, and all the original problems of intentionality, meaning, and reference still remain only, now regressed, are doubled and further compounded.

The problems that undermine closed-circle theory are thus both formal and empirical. The denial of a direction to the succession of paradigms or language games sets the evolutionary dynamics of the epistemic dimension in evolution writ large, and in the de facto time-asymmetric development of scientific theories in direct conflict with closed-circle theory. In addition, by confining meaning to human rule-based systems, closed-circle theory excludes the epistemic dynamics of life in general of which human culture is a dependent development. From a formal standpoint, the assertion of incommensurability, or absolute relativity of meaning, is incoherent since the assertion of the theory of closed-circles assumes a ground or basis for comparison to make the claim of incommensurability, and such a ground is denied by the assertion of incommensurability. This is exactly the 'Problem of Parmenides' who, as soon as he opened his mouth (or thought a thought) in the positing of his theory, violated its premises. Further, regressing or transposing the Cartesian circle to the cultural level retains all the old problems of intentionality and reference and adds the new problem of intersubjectivity. The assertion of intersubjectivity requires a contextualization or self-other relation for the individuals engaging in the epistemic act of intersubjectivity and this again assumes a ground or set of entailments which breaks the incommensurability of the Cartesian circle and with it the anti-realist premises of closed-circle theory. Finally, as has now been argued and shown from numerous perspectives, it is impossible, formally to get semantics or intentionality out of pure syntax which is just what closed-circle rule-based systems are (e.g., Fodor 1980; Hoffmeyer 1997; Lakoff 1987; Putnam 1980, 1981; see general discussion on rate-independent constraints in replicative ordering in Swenson 1991b, 1997c and Swenson and Turvey 1991; cf. Hoffmeyer's 1996a, 'code-duality'). In simple terms, no decontextualized or disembodied rules, symbols, algorithms, propositions, words, or even thoughts have ever been found, or ever will be since, as such, they would be entirely meaningless.

Evolutionary epistemology, hypothetical realism, and the 'situational logic' of natural selection

Evolutionary epistemologists who include Lorenz, Popper, and Campbell among others (e.g., see Callebaut and Pinxten 1987; Munz 1985; Radnitzky and Bartley 1987) have a view almost diametrically opposed to closed-circle theorists. Rather than being anti-realists they are avowed realists ('hypothetical realists'), and rather than being anti-evolutionists they base their entire theory on evolution, or, more particularly Darwinian evolutionary theory. Living things, as products of natural selection, to put it crudely, know true things about a real world or they would be dead. Living things and their behaviors, in effect, are hypotheses about the world and those that are 'truer' or have greater 'verisimilitude', are those with greater 'fitness' in Darwinian terms. Bad or 'false' hypotheses lead to death or extinction ('falsification'), and thus existence or persistence in some sense is proof, in effect, of knowing something 'true' about a 'real' world, and evolution writ large is seen as a continuous epistemic process of increasing knowledge, in Popper's words, 'from amoeba to man'. Scientific knowledge is seen as continuous with evolution in general, a process of selection of theories with greater truth content, universality, or verisimilitude by a process of trial and error or hypothesis proposal and falsification.

Evolutionary epistemology has a number of points that commend it, including first that, contrary to the time-symmetry or anti-evolutionism of closed-circle theory, it does not attempt to fly in the face of the empirical record. As a realist theory it avoids the *reductios* of closed-circle theory where truth (not simply what is thought about truth) is determined by the authority of a research community, or cultural system (e.g., if the authority of a cultural system holds that the holocaust did not occur, then it did not occur, or that pigs fly, then they fly). The realism of the evolutionary epistemologist is 'hypothetical'; however, in the sense that all 'truths', are subject to falsification. The 'justification' for hypothetical realism, as with most new realisms is de facto or heuristic rather than *de jure*, to use Hintikka's (1975) distinction. It is justified on a posteriori pragmatic grounds rather than following from a priori necessity. This is certainly not a fatal flaw since (following the assumption of largely Cartesian principles) it is widely held that a priori justification is impossible, and by the most reasonable demarcation criteria (e.g., Lakatos 1970; see Swenson 1997c for review) evolutionary epistemology easily 'wins' against the anti-realism of closed-circle theory. Of course the closed-circle theorist counters that applying such demarcation criteria assumes a common ground that its assertion of incommensurability denies, but as in the more general case above, such a counter goes down in flames with the recognition that it depends itself on the same ground or entailments that its assertion denies.

The problem with evolutionary epistemology is not that it has no a priori justification for its realism, but that as a result of its grounding in Darwinian theory ('neo-Darwinism') it must fail as an a posteriori theory on the question of intentionality and meaning. There are many varieties of Darwinism, but the core idea that unites them is the idea that evolution follows from natural selection (Depew and Weber 1995), and that natural selection is entailed by a situational logic (Popper 1985), namely, *if* certain conditions hold, then natural selection will necessarily follow. The problem is that one of the conditions is the intentional dynamics of living things (the others are heritable variability, and limited resources or the finiteness of space-time). Natural selection, said Darwin, follows from a population of replicating or reproducing entities with heritable variation 'striving to seize on every unoccupied or less well occupied space in the economy of nature' (1937 [1859]: 152). This latter ('the fecundity principle'), the idea in Schweber's (1985: 38) words, that nature acts in a way that 'maximizes the amount of life per unit area' refers precisely to the intentional dynamics of living things. But this makes intentional dynamics a primitive on which natural selection, and hence Darwinian theory depends as a consequence. Natural selection therefore does not explain intentional dynamics, but rather it is used instead to explain natural selection, and this puts it *ex hypothesi* beyond the explanatory framework of Darwinian theory. Darwinian theory begs a theory of intentionality; it does not, and cannot, by its own definition provide one (see Swenson 1997a, 1997b, 1997c; Swenson and Turvey 1991).

Space, time, space-time, and epistemologies 'outside tolerance'

During the formative years of the Cartesian worldview, space, following Newton, was considered separate from time and the particles that moved reversibly around in it as though it were some kind of a container. 'Reversibly' because time was little more than the notation (e.g., a plus or a minus sign) on the dynamical equations of motion and capable, as far as the governing laws were concerned, of 'flowing' either forward or back without prejudice. Irreversibility, or the one-way directedness of time we find in experience, did not find its way into the laws of physics until the second law of thermodynamics (see below) was recognized in the nineteenth century. Following the physics of Einstein, whereby the law of energy conservation (the first law of thermodynamics, see below) was extended to the recognition of matter as a form of energy, space, and time came to be inextricably linked in the notion of a space-time continuum. The idea of a continuum in this case expressing the conservation principle of the first law which captures the unity of all natural processes.

An important point that immediately follows is that space-time is not appropriately considered as a container in which things are put but instead as literally constituted or instantiated by things qua processes (or transformations of energy) themselves — no space-time, in this view, except as the instantiation of things or processes, and no things or processes (that are knowable, causally efficacious or within the 'event horizon') except as the instantiation of space-time. Figures 1–3, drawings

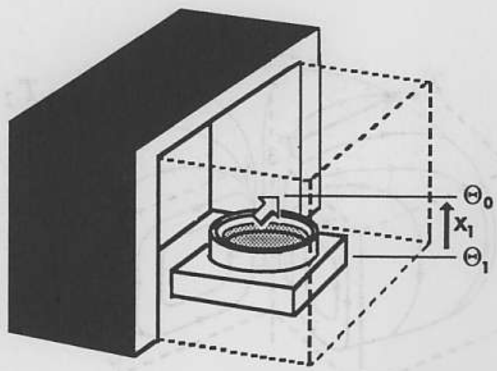

Figure 1. *The experimental set-up for the 'Bénard cell' experiment whereby a circular container of viscous liquid (silicon oil) is placed on top of a heated block of copper both of which are then placed in an adiabatic box (a box closed to all flows of energy in or out). The difference in temperature between the heated copper block below, Q_1, and the cooler air above, Q_2, constitutes a potential with a 'force' (the gradient of a potential), X_1, which produces a flow of heat through the fluid from the source to the sink (arrow)*

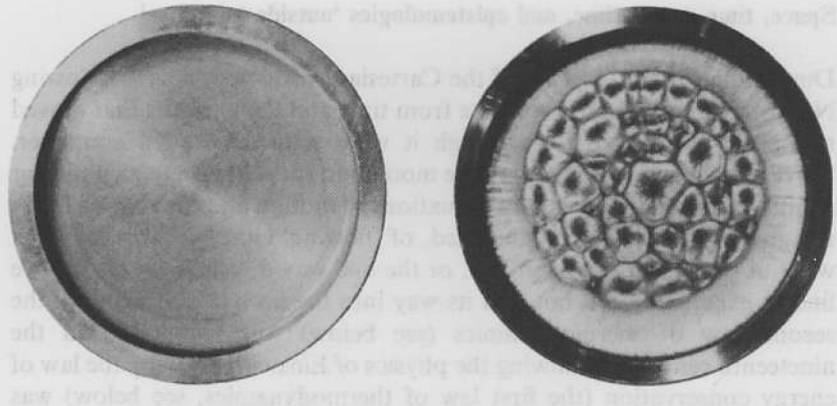

Figure 2. *When the gradient of the potential (the 'force') in the Bénard experimental is below a critical threshold (left) the flow of heat is produced by the random collision of the molecules (conduction), and the system is in the disordered or 'Boltzmann regime', and the surface of the system is smooth, homogeneous, and symmetrical. When the force is above the critical threshold (right), however, the symmetry of the system is broken and autocatakinetic order spontaneously arises as random microscopic fluctuations are amplified to macroscopic levels and 'Bénard cells' fill the container as hundreds of millions of molecules begin moving together. The change to the ordered autocatakinetic regime dramatically increases the rate at which the flow of heat moves from source to sink (for more detailed discussion see, e.g., Swenson 1989a, b, c, 1992, 1997a). (From Swenson [1989c]. Copyright 1989 Pergamon Press. Used by permission.)*

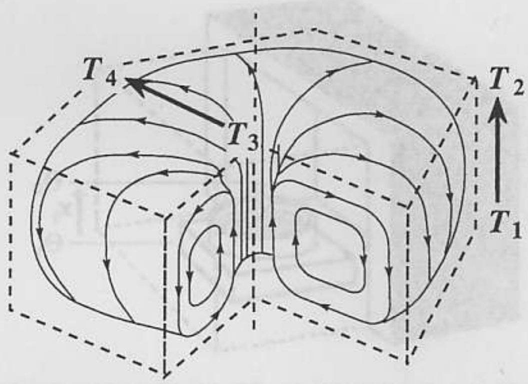

Figure 3. *The autocatakinetic flow constituting a Bénard cell is shown by the small arrows. $T_1 \rightarrow T_2$ is the heat gradient between the source and sink that motivates the flow. As heat rises through the center it creates a surface tension gradient $T_3 \rightarrow T_4$ which acts to further amplify the upward flow by pulling the hotter fluid to the cooler surrounds where it falls to the bottom to be heated again. (From Swenson [1997a]. Copyright 1977 JAI Press. Used by permission.)*

and photographs of the 'Bénard cell' experiment, an exemplar of the spontaneous transformation of disorder to order, or of self-organizing or autocatakinetic systems (see below), puts the discussion of space-time dimensions in concrete terms. Figure 1 shows the experimental set-up. Figure 2 shows the spontaneous transformation of disorder to order, and Figure 3 shows a schematic of a Bénard cell and the circular autocatakinetic relations that constituted it through the flow from source to sink.

The relation between order production, symmetry breaking, and the instantiation or development of space-time is readily seen. The spontaneous production of order constitutes a dramatic increase in the system's space-time dimensions. In the disordered regime in the Bénard experiment the intrinsic space-time dimensions, the dimensions given or instantiated by the system itself, are defined by mean free paths distances and relaxation times (the average distances and times between random or disordered collisions) which are on the order of 10^{-8} centimeters and 10^{-15} seconds. In the ordered regime, in contrast, the intrinsic space-time dimensions are on the order of seconds and centimeters. It takes the fluid some seconds to make the autocatakinetic cycle that constitutes each cell and the distance is measured in centimeters. Significantly, these new space-time dimensions do not exist in the disordered regime. They literally come into being with the production of order.

Another important point becomes clear with this understanding, namely, that from the hypothesized big bang until now, or in the four and a half billion years (4.5 GY) of evolution on Earth, what we are describing, in general terms, is the development of space-time. If we further understand the idea that no space-time except that instantiated, and no things or processes except as instantiated through or as space-time, then we understand that intentional dynamics itself constitutes a development or instantiation of space-time, and the deeper problem of intentionality is to understand exactly what this is and how it comes about. The very idea of the continuum as defined, it should be noted, automatically excludes incommensurable, or 'Cartesian' views. Such views put ontology and epistemology outside each others 'event horizons' or in each others 'null cones' forbidden by definition from existing with respect to each other (a restatement of the generic problem of interactionism).

The idea of an event horizon is illustrated in Figure 4. Figure 4a shows a two-dimensional representation of Newtonian space and time where instantaneous events faster than the speed of light are permitted, and 4b shows a two-dimensional representation of Minkowski space-time where, as is now taken to be the case, only events at or slower than the speed of

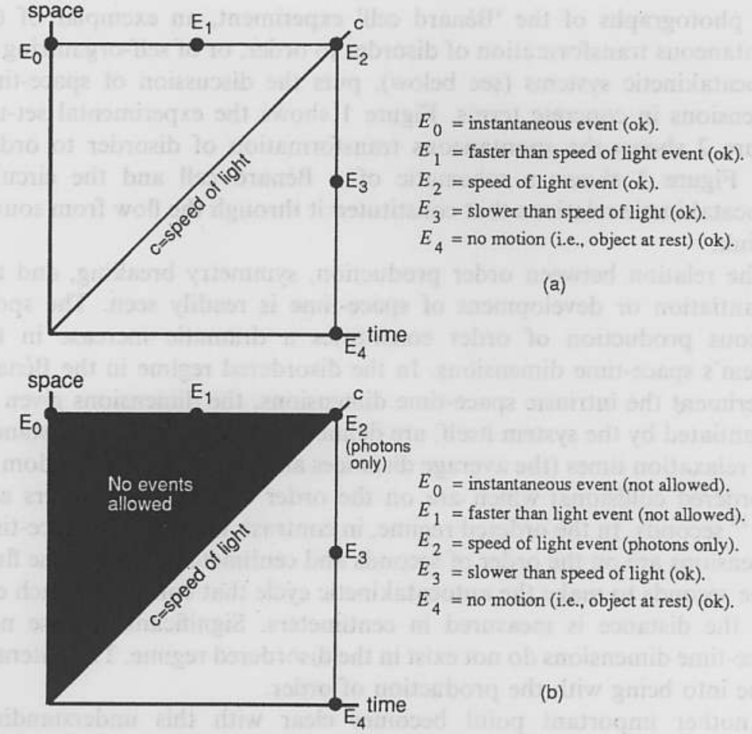

Figure 4. *Figure 4a shows a two-dimensional representation of Newtonian space and time, and Figure 4b shows a two-dimensional representation of Minkowski space-time. (After Shaw and Kinsella Shaw [1988].)*

light are permitted. The recognition of the speed of light as a speed limit on real-world dynamics sets up an event horizon or 'tolerance space', an idea particularly developed by Shaw (e.g., Barab et al., in press; Shaw and Kinsella-Shaw 1988) in the study of intentional dynamics, that reduces otherwise possible worlds to actual possibles. The more laws or invariant properties that are understood or the deeper the understanding the more otherwise possible worlds are collapsed onto actual states of affairs.

The core assumptions, or ontologies, of scientific theories can thus be understood as defining tolerance spaces that attempt to account for the forms that can and or do instantiate space-time in its development. The generic 'Problem of Parmenides' in these terms is the assertion of a tolerance space that does not account for or even accommodate the epistemic dimension. On pure 'rationalist' or logical grounds, Parmenides asserted a world of perfect symmetry, and hence a world where there was no space and time at all, but this put even the epistemic act implicated in his own postulating 'outside tolerance' with respect to his theory. He violated Parmenidean symmetry, and thus refuted himself every time he opened his mouth to speak, or even had a thought, and so it is, in effect, with the closed-circle theorists, and all other Cartesian-based theories in general.

'Return to *cogito*', and intentionality (qua 'epistemic act') and its entailments as the minimal ontology (the 'a priori' ground)

Recreating the 'Problem of Parmenides', Cartesian incommensurability puts the epistemic act, in whatever form, 'outside tolerance'. Ontologies aside, however, no one, from Parmenides to the present, has ever been able to get rid of the epistemic act in fact. The reversible world of quantum mechanics, for example, certainly productive in its own domain, needs the irreversible act of measurement, which sits completely unexplained outside its formalism, to 'collapse the wave function' (see Matsuno [1989] on generalized measurement). What remains, in every case, indubitably 'given', and in this sense Descartes's cogito argument was entirely correct, is the intentionality, or active 'directedness towards', of the self as agent caught in the epistemic act. But here is where we radically diverge from Descartes who postulated the epistemic act as a Cartesian circle, or pure, uncontextualized subject (an independent self, 'thinking I', or 'mind') and from which the whole 'epistemic problem' arises.

Contrary to Descartes it is just this uncontextualized subject that we certainly do not or cannot know (Swenson in press a). The 'I' or 'me' that is the subject of the epistemic act is bounded, discontinuous, or contextualized by implication, and as discontinuum only distinguishes itself or is even intelligible in relation to continuum, so too the self is only distinguished, or known, in relation to that which it is not (the not-self or other). Self-awareness, in other words, arises, establishes its identity, or is constituted only through a self-other, or subjective-objective relation, and the indubitable knowing of self 'given' in the epistemic act thus entails the knowing of the other (although not completely). In addition, there are further entailments.

In particular, the persistent or invariant (and hence nomological) self-other relations by which the self is known or determined — the epistemic act, in whatever form — only takes place through a one-way flow. The entailments here are two. The first is time-asymmetry, the 'one-wayness' of the flow, and the second is the conservation (time-symmetry) of that

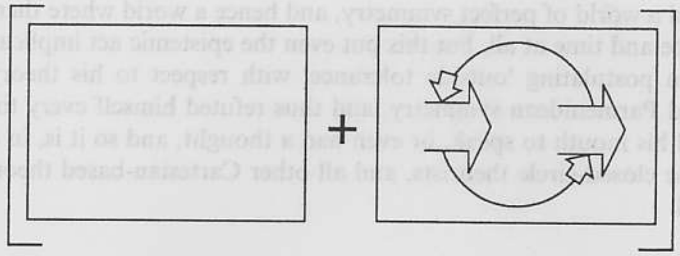

Figure 5. *A schematic of the conjunction capturing the 'minimal ontology' of the epistemic act. The left side represents the conservation (time-symmetry), that which is neither self nor other but out of which the self-other relation is constituted in the one-way flow. The right side shows the circularity of the self-other relation and the one-way flow (time-asymmetry) of the conservation through which it is constituted or distinguished. (From Swenson [1997c]. Copyright 1997 Lawrence Erlbaum and Associates. Used by permission.)*

which flows (there must be something which flows). Paraphrasing Leibniz to summarize, there must be something which changes and something which remains the same. Since these entailments are over the distinguishing self-other relations they refer not to either one or the other but both, a 'world' in effect, more encompassing than either one, a space-time continuum, precisely as discussed above, through which the relation is distinguished. It is precisely the a priori fact of these entailments that leads the closed-circle theorist to falsify him- or herself as soon as he or she opens his or her mouth, or engages in any other form of the epistemic act (e.g., in denial).

Figure 5 shows a schematic of the conjunction capturing the 'minimal ontology', or 'world', discussed thus far as entailed by the epistemic act. It undermines the Cartesian assertion of a decontextualized (or 'solipsistic') self collapsing otherwise possible worlds into a vastly reduced subset of real-world possibles where the onus is now on 'justifying' a possible world with a decontextualized self instead of the usual other way around. It sets tolerances on the minimal intentional (or cognitive, or epistemic) system. The fundamental 'directedness towards', or sine qua non of intentionality, the intentional content of the epistemic act, is the directedness towards the production of the self-other relations by which the space-time extension, or objectification (literally, the 'existence') of the self is constituted. Everything else with apparent intentional content, to the extent that it occurs (e.g., thoughts, representations, symbols, rules), in order that it has intentional content, ultimately serves, is contextualized by, parasitic upon, or differentiates out of these relations (see also Matsuno 1998).

Reconciling the two otherwise incommensurable 'rivers': Intentional dynamics as a universal entailment in the development of space-time (the a posteriori theory)

The previous section asserted that there are entailments which make a decontextualized view of intentionality or the epistemic act (or cognition, perception-action, and so on) untenable. It provides support for the increasing number of voices raised against intentionality based on decontextualized entities whether autonomous 'minds', mental representations, words, algorithms, propositions, or even 'intentions' as somehow autonomous entities themselves, and that argue variously instead for a contextualized, dynamic, or embodied theory of the epistemic dimension (e.g., Johnson 1987; Lakoff 1987; Talmy 1988; Thelen 1995; van Gelder and Port 1995). This does not dissolve the problem of 'universal contextualization', however. The fundamental 'problem of the two incommensurable rivers', and its various components, as noted above, remains. End-directed ordering dependent on meaning, or, in the language of the last section, intentional content directed toward space-time extension, is the 'signature' of the 'river' that flows uphill (of the epistemic dimension, or of biology, psychology, and culture), while the river of physics, according to the received view following Boltzmann's hypothesis of the 'entropy law', runs down to disorder (e.g., Fisher 1958 [1930]). A robust theory of biosemiotics, a naturalized or principled theory of intentionality, or truly dynamical, or 'embodied' theories of cognition must eliminate this problem.

As a result of this problem, however, evolutionists, as Levins and Lewontin (1985: 19) have noted, thus came to 'believe organic evolution to be a negation of physical evolution', and the idea is still very much alive as exemplified by Dennett's (1995: 69) definition of living things as things that 'defy' the entropy law, and his consequent argument that the source of all agency and meaning in the world is found in algorithms (see Swenson 1997c). As long as the two 'rivers' of physics and biology are held to be incommensurable the problem of the epistemic dimension must remain intractable because it is just at the interface between them, as noted above, that epistemic relations are distinguished (Hoffmeyer 1998; Swenson 1997a). Dynamics certainly has a very fruitful role to play (van Gelder and Port 1995), but dynamics per se cannot solve the problem since there is no inherent directedness or time-asymmetry in dynamical laws. One-way flow, on the other hand, is an entailment of the epistemic act (meaning, if the preceding section is understood, that it is a required condition of a possible world in which an epistemic act can take place), and this leads us directly to thermodynamics.

Symmetry, broken-symmetry, measurement, and the first and second laws of thermodynamics

The laws of thermodynamics are special laws that sit above the ordinary laws of nature, in effect, as laws about laws or laws upon which the other laws depend (Swenson and Turvey 1991). It can be successfully shown that without the first and second laws, which express symmetry properties of the world, there could be no other laws at all. The first law or the law of energy conservation which says that all real-world processes involve transformations of energy, and that the total amount of energy is always conserved, expresses time-translation symmetry. Namely, if you go forward or backward in time the total amount of energy remains the same. For example, the box in Figure 1 is sealed against all energy flows in or out, and although various dynamical processes take place within the box during the experiment the total amount of energy remains the same. As far as the first law is concerned, nothing has changed, and the world from the view of the first law is completely time-symmetric. The first law was first formulated in last century by Mayer, then Joule, and later Helmholz with the demonstration of the equivalence of heat and other forms of energy, and completed in this century with Einstein's demonstration, as noted above, that matter is also a form of energy. Figure 6 shows a famous experiment devised by Joule to demonstrate the first law.

The second law was formulated in the last century by Clausius and Thomson following the earlier work of Carnot who had observed that,

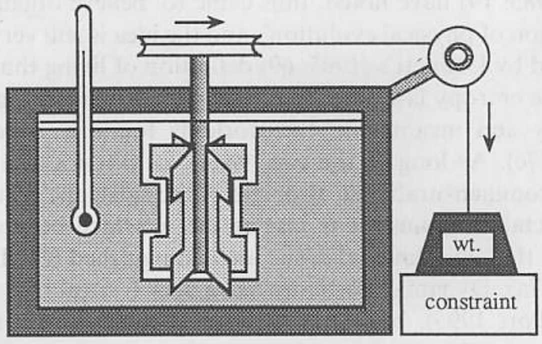

Figure 6. *The experiment devised by Joule to demonstrate the conservation of energy. When a constraint is removed, potential energy in the form of a suspended weight is converted into the kinetic energy of a moving paddle wheel in a container of water sealed against other inflow or outflow of energy. The moving paddle wheel heats the water by a precise amount consistent with the falling weight. (From Swenson [1997a]. Copyright 1997 JAI Press. Used by permission.)*

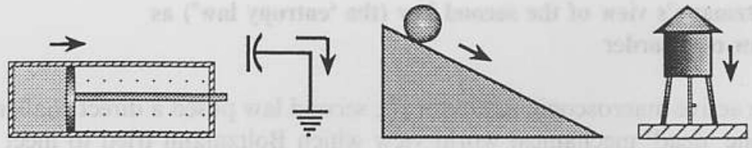

Figure 7. *Further examples of potentials that follow from nonequilibrium distributions of energy. Whenever energy (in whatever form) is out of equilibrium with its surroundings, a potential exists for producing change that, following the second law, is spontaneously minimized.*

like the fall or flow of a stream that turns a mill wheel, it was the 'fall' or flow of heat from higher to lower temperatures that motivated a steam engine. What was recognized here was that whenever an energy distribution is out of equilibrium a potential or thermodynamic 'force' (the gradient of a potential) exists that will spontaneously produce change or dynamics until it is dissipated or minimized. Clausius coined the term 'entropy' to refer to the dissipated potential and the second law, in its most general form, states that the world acts spontaneously to minimize potentials (or equivalently maximize entropy), and with this, active end-directedness or time-asymmetry was, for the first time, given a universal physical basis. The balance equation of the second law, expressed as $\triangle S > 0$, says that in all natural processes the entropy of the world always increases.

The active nature of the second law is intuitively easy to grasp and empirically demonstrate. If a cup of hot tea, for example, is placed in a colder room a potential exists and a flow of heat is spontaneously produced from the cup to the room until it is minimized at which point the temperatures are the same and all flows stop. Figure 7 shows various other potentials and the flows they would produce. Note that Joule's experiment (Figure 6) while designed to show the first law, unintentionally demonstrates the second, too. As soon as the constraint is removed the potential produces a flow from the falling weight through the moving paddle through the thermometer. This is precisely the one-way action of the second law and the experiment depends upon it entirely. The measurement of energy only takes place through the lawful flow or time-asymmetry of the second law, and the same is true of every measurement process. Every measurement process also demonstrates the first law as well since the nomological relations that hold require something that remains invariant over those relations (or else one could not get invariant or nomological results). The first and second laws are automatically given in every measurement process for the simple fact, in accordance with the discussion above, that they are entailed in every epistemic act.

Boltzmann's view of the second law (the 'entropy law') as a law of disorder

The active macroscopic nature of the second law posed a direct challenge to the 'dead' mechanical world view which Boltzmann tried to meet by reducing it to a law of probability following from the random collisions of mechanical particles (efficient cause). Using gas molecules modeled as billiard balls to make the point, Boltzmann argued that the second law was simply a consequence of the fact that since with each collision nonequilibrium distributions would become increasingly disordered leading to a final state of macroscopic uniformity and microscopic disorder. Because there were so many more possible disordered states than ordered ones, he concluded, a system will almost always be found either in the state of maximum disorder or moving towards it.

As a consequence, a dynamically ordered state, one with molecules moving 'at the same speed and in the same direction', Boltzmann (1974 [1886]: 20) asserted, is thus 'the most improbable case conceivable ... an infinitely improbable configuration of energy'. Because this idea works for certain near-equilibrium systems such as gases in boxes, and science until recently was dominated by near-equilibrium thinking, the idea of the second law as a law of disorder became widely accepted. But it is readily falsified. Order in simple physical experiments, such as the Bénard experiment (Figs. 1–3), is seen to arise not infinitely improbably, but with a probability of one, that is, every time and as soon as it gets the chance (Swenson and Turvey 1991), and this suggests a universality or nomological basis for active ordering.

Autocatakinetics and identity through flow

Machines or artifacts are defined by static order, the same components, external repairs excluded, in the same positions with respect to each other. Living things, from bacteria to cultural systems, in contrast, are spontaneously ordered or self-organizing systems defined by dynamic order. Because the terms 'spontaneous order' and 'self-organizing' are used in the literature in many non-equivalent and unrelated ways, the more technical term 'autocatakinetic' is used here to make the meaning here clear. Self-organizing or spontaneously ordered systems as autocatakinetic systems are systems whose identities are constituted with a set of circularly causal relations through the continuous flux of their components in the breakdown or dissipation of environmental or field potentials (Swenson 1991a, Swenson and Turvey 1991). Persistence

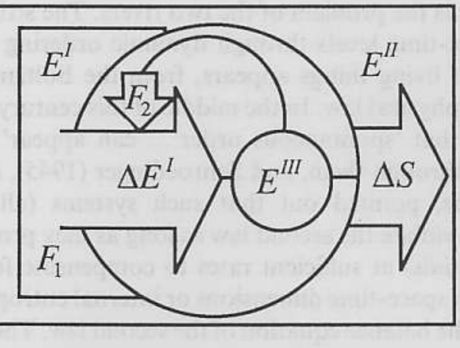

Figure 8. *A generalized autocatakinetic system.* E^I *and* E^{II} *indicate a source and a sink with the difference between them constituting a field potential with a thermodynamic force* F_1 *(a gradient of a potential) the magnitude of which is a measure of the difference between them.* $\triangle E^I$ *is the energy flow at the input, the drain on the potential which is transformed into entropy production* $\triangle S$ *at the output.* E^{III} *is the internal potential carried in the circular relations that define the system by virtue of its distance from equilibrium that acts back to amplify or maintain input during growth or non-growth phases respectively with an internal force* F_2. *(From Swenson [1989b]. Copyright 1989 by Pergamon. Adapted by permission.)*

(the form of the thing) at the 'macro' level is constituted by change at the 'micro' level through the flux pulled in across the system's boundaries and expelled in a more degraded form (e.g., see Fig. 3).

Figure 8 shows a schematic drawing of an autocatakinetic system. Since Bénard cells as well as dust devils, hurricanes, and tornadoes, for example, are autocatakinetic systems the class of such systems goes well beyond the living, a fact which suggests a universality to spontaneous dynamic ordering.

Of significant theoretical interest with respect to this article is that autocatakinetics of the living is distinguished from the non-living by its intentional content. Non-living things, in effect, are 'slaves' of their local potentials (e.g., remove the heat source from the Bénard cell and it 'dies'), but the autocatakinesis of the living is characterized by 'intentional dynamics', that is, dynamics maintained with respect to non-local potentials through meaningful relations or 'information about'. As noted above, the production of order from disorder instantiates new space-time dimensions, and planetary evolution can be seen as the development of space-time through the progressive production of higher states of order. The point here is that it is precisely through the intentional dynamics of the living that relations are constituted across non-local potentials and these otherwise inaccessible dimensions of space-time are accessed, and it is in the directedness, or urgency towards the production of such relations, as noted above, that the *sine qua non* of intentionality is found.

But here now is the problem of the two rivers. The striving, in effect, to instantiate space-time levels through dynamic ordering expressed in the intentionality of living things appears, from the Boltzmann view, to go directly against physical law. In the middle of this century, von Bertalanffy (1952) showed that 'spontaneous order ... can appear' in systems with energy flowing through them, and Schroedinger (1945), comparing living things to flames, pointed out that such systems (all autocatakinetic systems) do not violate the second law as long as they produce entropy (or minimize potentials) at sufficient rates to compensate for their ordering (their increase in space-time dimensions or internal entropy reduction) and thereby satisfy the balance equation of the second law. The idea was further popularized by Prigogine (1978) under the name of 'dissipative structures'. But whereas such systems were seen as 'permitted' to exist, given the classical view of the second law, according to the Boltzmann view they were still 'infinitely improbable'. The question of why order is seen to arise whenever it gets the chance — in simple physical systems, in the evolutionary record writ large (e.g., see Swenson and Turvey 1991; Swenson 1997b, c), in the 'fecundity principle' on which Darwinian theory depends, and in the directedness towards that which characterizes the intentional content of the epistemic act itself — remained.

The law of maximum entropy production or why the world is in the order production business

The solution to the puzzle is found in two parts. The first is the recognition of an important point in the Bertalanffy-Schroedinger-Prigogine contribution that was not stated directly by them. In particular, since to come into being and persist a dynamically ordered system must increase the rate of entropy production of the system plus environment at a sufficient rate to satisfy the balance equation of the second law, ordered flow, according to the balance equation, must be more efficient at dissipating potentials than disordered flow. Now this becomes important only with the second part of the solution, which is the answer to a question classical thermodynamics never asked. In particular, which path(s) out of available paths will a system take to minimize potentials or maximize the entropy? The answer (the 'law of maximum entropy production') is the path or assembly of paths that minimizes the potential (maximizes the entropy) at the fastest rate given the constraints (Swenson 1988, 1989d, 1991a, b, 1997a, b; Swenson and Turvey 1991).

Like the second law, the law of maximum entropy production is intuitively easy to grasp and empirically demonstrate. Imagine any out-of-equilibrium system with multiple available pathways such as a heated cabin in the middle of snowy woods (Swenson and Turvey 1991). In this case, the system will produce flows through the walls, the cracks under the windows and the door, and so on, so as to minimize the potential. What we all know intuitively (why we keep doors and windows closed in winter) is that whenever a constraint is removed so as to provide an opportunity for increased flow the system will reconfigure itself so as to allocate more flow to that pathway. In short, no matter how the system is arranged, the pattern of flow produced will be the one that minimizes the potential at the fastest rate given the constraints. Once understood, examples of this deceivingly simple physical principle are easy to proliferate (e.g., Goerner 1994; Peck in press).

But now what does that law of maximum entropy production have to do with order production? The reader may have already jumped to the correct conclusion, namely, *if* ordered flow produces entropy faster than disordered flow (the balance equation of the second law), *and if* the world acts to minimize potentials at the fastest rate given the constraints (the law of maximum entropy production), *then* the world can be expected to produce order, to instantiate new space-time dimensions, whenever it gets the chance. Thus the world, in slightly different terms, can be expected to act opportunistically to extend the dimensions of space-time through the spontaneous production of dynamical order as fast as it can because potentials are thereby minimized at a faster rate. The world is in the order production business because ordered flow produces entropy faster than disordered flow, and this, in most direct terms, provides the nomological basis for the reconciliation of the otherwise two incommensurable rivers. Rather than being anomalous with respect to, or somehow violating physical or unversal law, the 'river that flows uphill' that characterizes the active epistemic dimension of the world is seen to be a direct manifestation of it, an entailment of universal law.

The semantic content of macroscopic flow variables in the intentional dynamical context

If the foregoing provides the universal basis for intentional dynamics in general, the de facto question concerning semantic content in the intentional dynamical context still needs addressing. In particular, if intentionality is minimally defined as a kind of dynamics distinguished through the production and maintenance of persistent or invariant self-other relations rather than a property of decontextualized mental states or representations (or algorithms or symbols) in Cartesian circles, then there must be semantic content available in the world itself and it must be nomologically specified. There must be a lawful basis, in other words, for meaningful specification in the proximal present of intentional ends in the distal future.

We could simply point out based on our previous arguments, or as the evolutionary epistemologists do (based on the existence of living things), that such content is entailed, but this still begs the whole question of how is it effected. The answer was first appreciated by Gibson (1986 [1979]; Swenson and Turvey 1991; Turvey and Shaw 1995) with his ecological conception of information. Living things are macroscopic systems that maintain their autocatakinesis through the context of macroscopic flow, and what Gibson correctly concluded was that the place to look for meaningful content was not in the normal physical descriptors of individual particles, but instead in the variables of the flow itself. Specifically, what he recognized was that the ambient energy flows (e.g., optical, mechanical, chemical) in which living things are embedded carry invariant macroscopic properties that lawfully specify, and thus carry semantic content with respect to, or 'information about', their sources. This information can then be used directly in the lawful proximal control of behavior towards distal intentional ends.

Optic flow variables, for example, can lawfully specify 'time-to-contact' (e.g., Lee 1980; Kim et al. 1993; Swenson 1997a), or a chemical or optical gradient can lawfully specify the source of food (see also Swenson and Turvey [1991] on the origin of vision), and diffusion and mechanical fields (e.g., see Peck [in press] on the origin of hearing) can be used in similar ways (e.g., see Lee 1980; Kim et al. 1993; Swenson 1997a; Swenson and Turvey 1991; Turvey and Shaw 1995). The major contribution of this deceivingly simple insight is that it gets meaning outside of heads or disembodied mental states and into the context of intentional dynamics and its entailments, or into the world itself. It shows precisely how the invariant self-other relations through which intentional dynamics are instantiated are maintained. It is of particular interest, although Gibson did not note it, that the invariant macroscopic properties to which he pointed are precisely a consequence of first law symmetry, or the time-symmetry, of the space-time continuum itself (Swenson 1997a).

Intentional inexistence, direct perception, and the time-asymmetry of learning

Contrary to Cartesian theories that assert meaning and intentionality is 'in the head' and perception is of mental objects ('indirect perception'), Gibson's theory of perception is called 'direct' because what it means by perception is the pick-up of invariant properties of the world, and in this it provides a principled basis for understanding one of the fundamental entailments of the epistemic act (the maintenance of persistent, invariant self-other relations). Gibson's theory has been criticized, however, because it is said it fails to account for errors or failed intentions based on what Brentano (1973 [1894]) called 'intentional inexistence' (non-existent objects of the imagination, e.g., the failure to find and slay a unicorn, the failure of a human to flap his or her arms and fly, the failure of a predator to catch an intended prey, or the failure of a hypothesis of any kind) (e.g., Berry 1997).

It is true that Gibson's theory of direct perception does not account for intentional inexistence because objects of the imagination, by definition, are not objects of perception for Gibson. But this is why if Gibson's contribution is to be appreciated it must be recognized that it is not a theory of intentionality per se, but instead of a crucial component of intentionality (the nomological ground for semantic content). Lacking relational entailments, closed-circle theories (which, as argued above thus immediately falsify themselves as soon as they are posited) are forced to conflate intentionality and perception as derivations from or about mental representations. Beyond showing the nomological ground for the entailment of invariant relations, and calling that 'perception', Gibson's contribution shows that intentionality, unless one denies intentional inexistence or failed intentions, can no longer be conflated with perception.

Perceiving, for Gibson, referring to the nomological relations that hold during the execution of a successful intention, such as when a bird lands softly on a branch, thus means picking up on the invariant relations that lawfully specify the conditions for the successful execution (viz., in this case the inverse rate of expansion of the optic flow enveloping the bird, e.g., see Lee [1980]; Kim et al. [1993]; Swenson [1997a, in press a]). It means knowing the world *qua* invariant properties (symmetries or laws). But 'failed intentions' surely exist, and beyond that if intentional dynamics were conflated with perception as nomologically defined there would be no learning, no evolution, no time-asymmetry with respect to the epistemic or intentional dimension of the world, or no development of space-time to talk about, and, in fact, no talking or postulating at all. Learning is a time-asymmetric process by definition, and as much as nomological relations are entailed in the epistemic act, so too, in a developing world where initial conditions are never the same twice, is exploratory action from ignorance or failed intentions (or 'random' acts). Phylogenetically, ontogenetically, or at whatever scale, epistemic ordering must begin, in effect, in ignorance, and actions, and particularly failed intentions, or trial and error, must therefore precede knowing or learning the laws.

Contrary to Laplacean or mechanistic determinism in which causality is reduced to efficient cause and like antecedents lead to like consequents (e.g., see criticisms of efficient causality in Juarero [in press]; Salthe [1985, 1993]; Swenson [1990, 1991a, b, 1997a]) intentional dynamics is characterized by macrodeterminacy, or end-specific dynamics, to use Dyke's (1997) felicitous term, where unlike antecedents or starting conditions lead to the same consequence. Indeed end-specificity, macrodeterminacy, or insensitivity to initial conditions is a generic property of autocatakinetic systems (e.g., see Swenson [1997a] for detailed discussion of insensitivity to initial conditions and the Bénard cell experiment). The generic symmetry-breaking dynamics includes stochastic seeding, or 'blind variation' that leads to a nomologically determinate end-specific result at the macrolevel. Intentional dynamics is a development of this same dynamic built on invariant macroscopic properties, or information about, between discontinuously located potentials.

Random actions, trial and error, actions from ignorance, or what can be thought of as 'generalized intentional inexistence' (micro indeterminacy in macrodeterminate fields) develops to the special case of intentional inexistence invoked by Brentano (e.g., mental representations of imaginary objects) in human cultural systems where the more fundamental forms of intentional dynamics become linguistically embodied (Johnson 1987; Lakoff 1987; Talmy 1988). The result is the dramatic expansion of event horizons providing new means to explore, discover, and thereby instantiate new and otherwise inaccessible dimensions of space-time through opportunistic ordering (see also Dyke 1997 on space-time expansion in cultural systems, and Swenson 1991b, 1997a, c; Swenson and Turvey 1991; see also the development of 'semiotic freedom' in Hoffmeyer 1996b).

Conclusion

Summarizing briefly, modern science, built on Cartesian metaphysics, has had at its core a set of postulates of incommensurability that preclude an understanding of the epistemic dimension of the world, of intentional dynamics, or end-directed ordering dependent on meaning (semantic content, or 'aboutness'). The assumption first of the incommensurability between psychology and physics (between knower and known, self and other, subject and object, mind and matter), and later between physics and biology (or between living things and their environments in general) has left modern science with the 'Problem of Parmenides', with a physical world or ontology that cannot account for or even accommodate the epistemic act of the subject doing the postulating. The bottom literally falls out from under the ground of modern science on this issue because beyond the obvious discourses of relevance (e.g., psychology, cognitive science, philosophy of mind, biology, evolutionary theory, and ecology), science itself, in whatever form, is a paradigmatic epistemic activity. What counts as fundamental science must as a consequence be able to account at its core for the active, end-directed epistemic or intentional fact of the epistemic act itself as an *a priori* 'given' or pre-condition for anything that is known, thought, or felt, including, most particularly, any notion of self-awareness whatsoever. In different terms, if the *a priori* and *a posteriori* do not, in effect, collapse to the same subset of possible worlds, then the 'Problem of Parmenides' remains.

Historically, the problem in modern science is traced to Descartes's dualist metaphysics where physics and psychology were literally defined by their mutual exclusivity. The physical part of the world was taken to be exhaustively defined by extension in space and time, and consist of reversible, qualityless, inert or 'dead' particles ('matter') governed by efficient cause and rigid deterministic law from which the active, striving immaterial 'mind' (the self, 'thinking I', or psychological part) without spatial or temporal dimension, was said to be immune. The physical world, thus described, incapable of ordering itself, and extensionally defined, had to have order, intentionality, and meaning imposed on it from outside by 'mind'. Cartesian incommensurability came full-blown into biology through Kant and with the later rise of Darwinian evolutionary theory which was based on the assumptions of Boltzmann's thermodynamics. Recognizing that the active, end-directed striving of living things could not be accounted for from within the 'dead' world of physics Kant, arguing for the autonomy of biology from physics rather than recognizing a need for a revision of physics, promoted a second major dualism, the dualism between biology and physics, or between living things in general and their environments. Boltzmann's view of the second law of thermodynamics as a universal law of disorder provided the basis for fully entrenching the postulates of incommensurability in supposed physical law. The transition from disorder to order, he asserted, was infinitely improbable. The world came to be seen as two incommensurable 'rivers', the river of physics flowing down to disorder, and the river of biology and psychology, the 'river' comprising the epistemic dimension of the world or the intentional dynamics of living things, flowing up to increasingly higher levels of order. The active, directedness towards (or 'aboutness'), or *telos* constituting the intentionality of the epistemic act, and the semantic content on which it depends, were seen not only as outside of physical law, but entirely anomalous with respect to it.

This view seemed to support, and seemed to be supported by, Descartes's famous *cogito ergo sum* the assertion of the independent thinking 'mind' (the Cartesian self, or thinking I) as indubitably 'given', and by his consequent theory of perception. 'Independent' thinking mind because all its characteristic properties, according to this view, do not exist in the physical world. The result was that perception, by definition intentional (characterized by 'aboutness') could only be of mental states ('indirect perception'), not of the world, and the epistemic dimension of the world by necessity became a closed circle (the 'Cartesian circle') constituting the human mind with no way in or out and no rational basis for justifying belief in an 'outside', external, or objective world (the 'other') at all. Epistemology and ontology, in effect, were put in each other's null cones, and here we find basis for 'the epistemic problem' that has plagued modern psychology, philosophy, and every other discourse where intentionality, or the epistemic dimension, or 'mind' in nature is a central issue (which, in effect, given the discussion above, directly or indirectly, is every discipline and discourse, and the very foundations of science itself). The computational view of mind that has dominated cognitive science in recent years where all meaning and intentionality is placed internal to rule-based systems of operations on symbols or mental representations is a mechanized version of the Cartesian circle which also came to be transposed to the social psychological level in the various forms of 'closed-circle theory'. In this case, with the addition of intersubjectivity, all the original fatal formal and empirical problems remained only further compounded.

But the entire 'epistemic problem', the general problem of intentionality, meaning, or knowing, is built on a set of insupportable assumptions, and it is from the assumptions that the problem arises. In short, the 'independent mind' or self, the Cartesian *a priori* or 'given' asserted in the *cogito* argument is a myth, and the *a posteriori* view of the 'two incommensurable rivers' is now readily shown to be false. With respect to the first, there is no independent, decontextualized subject or self. As discontinuum is related to continuum, the self or subject is only distinguished, known, is only 'given' relationally through the self-other dynamics of the epistemic act, and the epistemic act with its relational entailments provides a minimal ontology or 'world' on which the existence of the self thus inextricably depends. From an *a posteriori* point of view, while both the urgency towards dynamical ordering and the availability of semantic content 'in the world', the characteristic properties of what is properly referred to as 'intentional dynamics', are entirely anomalous from the older view of the two incommensurable rivers, we are now able to show instead that they are expected consequences of natural law.

Firstly, Boltzmann's assertion that the production of order from disorder is infinitely improbable is falsified not only by the ubiquity of epistemic ordering, or the epistemic act itself as well as the evolutionary record writ large, but by simple repeatable physical experiments where spontaneous ordering occurs with a probability of one and as soon as it gets the chance. This suggests a universality of which intentional dynamics is a special case, and it is found in the 'law of maximum entropy production', in particular, the fact that the world acts to minimize potentials or gradients (to maximize the entropy) at the fastest rate given the constraints. Since, given the balance equation of the second law, the transition from disordered to dynamically ordered states dramatically increases the rate of entropy production, the world can be expected to produce order, or to instantiate new dimensions of space-time whenever it gets the chance. The world is in the order production business, or can be expected to produce as much order as it can, because ordered flow produces entropy faster than disordered flow.

Intentional dynamics, by providing the means to build dynamical order across non-local potentials through the use of information about, provides access to vast otherwise inaccessible dimensions of space-time, or dynamic order. Proximal information about distal potentials is nomologically specified in the invariant macroscopic properties of ambient energy flows as a consequence of first law symmetry, and from these points we find the basis for solving the problem of the two 'rivers' and dissolving the old postulates of incommensurability (e.g., between knower and known, subject and object, or the 'mental' and the 'physical'). We find the basis for disposing of the 'Problem of Parmenides' and building a principled foundation to a theory of intentionality where what is given *a priori* as the intentionality of the epistemic act, and *a posteriori* as the epistemic development of space-time collapse onto the same subset of possible worlds, and thus rather than being 'outside tolerance' with respect to natural or universal laws is seen instead to be a direct manifestation of them.

Notes

* Special thanks, as always, to the Center for the Ecological Study of Perception and Action for their ongoing support, to Bill Mace, Koichiro Matsuno, and Bob Shaw for useful discussions, and to the guest editors of this special issue, Claus Emmeche and Jesper Hoffmeyer, for their efforts in producing this volume, and particularly for their

patience. Preparation of this manuscript was supported in part by National Science Foundation Grant #SBR9422650. All points of view and consequent errors are mine.

1. A 'principled account' in most general terms is an account which entails entailments (defined in the text), but here I use it in the stronger sense of universal entailment. In this sense it is equivalent to my use of 'naturalized account' or one following from natural law.

References

Barab, S.; Cherkes-Julkowski, M.; Swenson, R.; Garretts; and Shaw, R. (in press). Principles of self-organization: Learning as participation in autocatakinetic systems. *Journal of Learning Sciences.*

Berry, M. (1997). Intention and perception. Unpublished manuscript.

Boltzmann, L. (1974 [1886]). The second law of thermodynamics. In *Theoretical Physics and Philosophical Problems*, S. G. Brush (trans.), 13–32. Boston: D. Reidel.

Brentano, F. (1973 [1894]). *Psychology from an Empirical Standpoint.* New York: Humanities Press.

Callebaut, W. and Pinxten, R. (eds.) (1987). *Evolutionary Epistemology: A Multiparadigm Program.* Dordrecht: D. Reidel.

Campbell, D. T. (1987). Evolutionary epistemology. In *Evolutionary Epistemology, Rationality, and the Sociology of Knowledge*, G. Radnitzky and W. W. Bartley III (eds.), 47–89. La Salle, IL: Open Court.

Darwin, C. (1937 [1859]). *On the Origin of Species by Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life.* New York: D. Appleton-Century Company.

Dennett, D. (1995). *Darwin's Dangerous Idea: Evolution and the Meanings of Life.* New York: Simon & Schuster.

Depew, D. and Weber, B. (1995). *Darwinism Evolving.* Cambridge, MA: MIT Press.

Dyke, C. (1997). Heuristics of ecological interaction. *Advances in Human Ecology* 6, 49–97.

Eddington, A. (1958). *The Nature of the Physical World.* Ann Arbor, MI: Ann Arbor Paperbacks.

Fisher, R.A. (1958 [1930]). *The Genetical Theory of Natural Selection.* New York: Dover.

Fodor, J. A. (1980). Methodological solipsism considered as a research strategy in cognitive psychology. *Behavioral and Brain Sciences* 3, 63–109.

Gibson, J. J. (1986 [1979]). *The Ecological Approach to Visual Perception.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Goerner, S. (1994). *Chaos and the Evolving Ecological Universe.* New York: Gordon & Breach.

Hintikka, J. (1975). *The Intentions of Intentionality and Other New Models for Modalities.* Boston: D. Reidel.

Hoffmeyer, J. (1996a). Evolutionary intentionality. *The Third European Conference on Systems Science, Rome, 1–4 October 1996*, E. Pessa, A. Montesanto, and M. P. Penna (eds.), 699–703. Rome: Edzioni Kappa.

— (1996b). *Signs of Meaning in the Universe*, trans. by B. J. Haveland. Bloomington: Indiana University Press.

—(1997). Semiotic emergence. *Contemporary Thought* 25/27 (6), 103–117. [In Japanese.] English version available at: (http://www.molbio.ku.dk/MolBioPages/abk/PersonalPages/Jesper/SemioEmergence.html).

—(1998). The unfolding semiosphere. In *Evolutionary Systems*, G. van de Vijver, S. Salthe, and M. Delpos (eds). Dordrecht: Kluwer.

Johnson, M. (1987). *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason.* Chicago: University of Chicago Press.
Juarrero, A. (in press). *Dynamics in Action: Intentional Behavior as a Complex System.* Cambridge, MA: Bradford Books.
Kim, N.; Turvey, M. T.; and Carello, C. (1993). Optical information about the severity of upcoming collisions. *Journal of Experimental Psychology* 19 (1), 179–193.
Lakatos, I. (1970). Falsification and the methodology of scientific research programmes. In *Criticism and the Growth of Scientific Knowledge*, I. Lakatos and A. Musgrave (eds.), 91–195. Cambridge: Cambridge University Press.
Lakoff, G. (1987). *Women, Fire, and Dangerous Things: What Categories Reveal about the Mind.* Chicago: University of Chicago Press.
Levins, R. and Lewontin, R. (1985). *The Dialectical Biologist*. Cambridge, MA: Harvard University Press.
Lee, D. (1980). A theory of visual control of braking based on information about time-to-collision. *Perception* 5, 437–459.
Lorenz, K. (1973). *Behind the Mirror: A Search for a Natural History of Human Knowledge.* New York: Harcourt Brace Jovanovich.
Matsuno, K. (1989). *Protobiology: Physical Basis of Biology*. Boca Raton, FL: CRC Press.
—(1998). On the principle of maximum entropy production. In *Perspectives on Affordance*, M. Sasaki (ed.), in press. Tokyo: University of Tokyo Press. [In Japanese.]
—(1999). The clock and its triadic relationship. *Semiotica* (this issue).
MacKay, D. (1986). Intrinsic versus contrived intentionality. *Behavioral and Brain Sciences* 9, 149–150.
Munz, P. (1985). *Our Knowledge of the Growth of Knowledge: Popper or Wittgenstein?* London: Routledge & Kegan Paul.
Peck, A. J. (in press). Hydrodynamics, reactive forces, and the autocatakinetics of hearing. *Ecological Psychology*.
Popper, K. (1985). *Unended Quest: An Intellectual Autobiography*. La Salle, IL: Open Court.
Prigogine, I. (1978). Time, structure, and fluctuations. *Science* 201, 777–785.
Putnam, H. (1980). Models and reality. *Journal of Symbolic Logic* 45, 464–482.
—(1981). *Reason, Truth, and History*. Cambridge: Cambridge University Press.
Radnitzky, G. and Bartley, W. W., III (1987). *Evolutionary Epistemology, Rationality, and the Sociology of Knowledge*. La Salle, IL: Open Court.
Salthe, S. (1985). *Evolving Hierarchical Systems*. New York: Columbia University Press.
—(1993). *Evolution and Development*. Cambridge, MA: MIT Press.
Sayre, K. (1986). Intentionality and information processing: An alternative model for cognitive science. *Behavioral and Brain Sciences* 9, 121–166.
Schroedinger, E. (1945). *What Is Life?* New York: Macmillan.
Schweber, S. (1985). The wider British context of Darwin's theorizing. In *The Darwinian Heritage*, D. Kohn (ed.), 35–69. Princeton, NJ: Princeton University Press.
Shaw, R. and Kinsella-Shaw, J. (1988). Ecological mechanics: A physical geometry for intentional constraints. *Human Movement Science* 7, 155–200.
Shaw, R.; Kadar, E.; Repperger, D.; and Sim, M. (1992). The intentional spring: A strategy for modeling systems that learn to perform intentional acts. *Journal of Motor Behavior* 24 (1), 3–28.
Shaw, R.; Kadar, E.; and Kinsella-Shaw, J. (forthcoming). Modelling systems with intentional dynamics: A lesson from quantum mechanics.
Swenson, R. (1988). Emergence and the principle of maximum entropy production: Multilevel system theory, evolution, and non-equilibrium thermodynamics. *Proceedings of the 32nd Annual Meeting of the International Society for General Systems Research*, 32–49.

—(1989a). Engineering initial conditions in a self-producing environment. In *A Delicate Balance: Technics, Culture and Consequences* (=IEEE Catalog No. 89CH291–4), M. Rogers and N. Warren (eds.), 68–73. Los Angeles: Institute of Electrical and Electronic Engineers.
—(1989b). Emergent evolution and the global attractor: The evolutionary epistemology of entropy production maximization. *Proceedings of the 33rd Annual Meeting of The International Society for the Systems Sciences* 33 (3), 46–53.
—(1989c). Emergent attractors and the law of maximum entropy production: Foundations to a theory of general evolution. *Systems Research* 6, 187–198.
—(1989d). Gauss-in-a-box: Nailing down the first principles of action. *Perceiving-Acting Workshop Review* (=Technical Report of the Center for the Ecological Study of Perception and Action) 5, 60–63.
—(1990). Evolutionary systems and society. *World Futures* 30, 11–16.
—(1991a). End-directed physics and evolutionary ordering: Obviating the problem of the population of one. In *The Cybernetics of Complex Systems: Self-Organization, Evolution, and Social Change*, F. Geyer (ed.), 41–60. Salinas, CA: Intersystems Publications.
—(1991b). Order, evolution, and natural law: Fundamental relations in complex system theory. In *Cybernetics and Applied Systems*, C. Negoita (ed.), 125–148. New York: Marcel Dekker.
—(1992). Autocatakinetics, yes — Autopoiesis, no: Steps towards a unified theory of evolutionary ordering. *International Journal of General Systems* 21 (2), 207–228.
—(1997a). Autocatakinetics, evolution, and the law of maximum entropy production: A principled foundation toward the study of human ecology. *Advances in Human Ecology* 6, 1–46.
—(1997b). Thermodynamics, evolution, and behavior. In *The Handbook of Comparative Psychology*, G. Greenberg and M. Haraway (eds.), 217–288. New York: Garland Publishing.
—(1997c). Evolutionary theory developing: The problem(s) with 'Darwin's Dangerous Idea', *Ecological Psychology* 9 (1), 47–96.
—(1998). Autocatakinetics, the minimal ontology, and the constitutive logic of ecological relations. *Revue de la Pensee d'Ajour d'Hui (Japanese Journal of Contemporary Philosophy)* 25/26 (May), 244–259. [In Japanese.]
—(in press a). Spontaneous order, evolution, and autocatakinetics: The nomological basis for the emergence of meaning. In *Evolutionary Systems*, G. van de Vijver, S. Salthe, and M. Delpos (eds.). Dordrecht: Kluwer.
—(in press b). *Spontaneous Order, Evolution, and Natural Law: An Introduction to the Physical Basis for an Ecological Psychology*. Hillsdale, NJ: Lawrence Erlbaum.
Swenson, R. and Turvey, M. T. (1991). Thermodynamic reasons for perception-action cycles. *Ecological Psychology* 3 (4), 317–348.
Talmy, L. (1988). Force dynamics in language and cognition. *Cognitive Science* 12, 49–100.
Thelen, E. (1995). Time-scale dynamics and the development of an embodied cognition. In *Mind in Motion*, T. van Gelder and R. Port (eds.), 69–100. Cambridge, MA: MIT Press.
Turvey, M. T. and Shaw, R. E. (1995). Towards an ecological physics and a physical psychology. In *The Science of the Mind: 2001 and Beyond*, R. Solso and D. Massero (eds.), 144–169. Oxford: Oxford University Press.
Turvey, M. T.; Shaw, R.; Reed, E.; and Mace, W. (1981). Ecological laws of perceiving and acting: In reply to Fodor and Pylyshyn (1981). *Cognition* 9, 237–304.
Van Gelder, T. and Port, R. (1995). It's about time: An overview of the dynamical approach to cognition. In *Mind in Motion*, T. van Gelder and R. Port (eds.), 1–45. Cambridge, MA: MIT Press.
Von Bertalanffy, L. (1952). *Problems of Life*. London: Watts.

Rod Swenson (b. 1945) is a Research Fellow and Lecturer at the University of Connecticut and the Center for the Ecological Study of Perception and Action ⟨ros95001@uconnum.uconn.edu⟩. His principal research interest is evolution and the epistemic dimension. His major publications include 'Order, evolution, and natural law: Fundamental relations in complex system theory' (1991), 'Thermodynamic reasons for perception-action cycles' (with M. T. Turvey, 1991), and 'Autocatakinetics, evolution, and the law of maximum entropy production: A principled foundation toward the study of human ecology' (1997).