Handbook of Research on Strategy and Foresight

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1 Redefining strategic foresight: 'fast' and 'far' sight via complexity science

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Introduction

> The only thing that gives an organization a competitive edge – the only thing that is sustainable – is what it knows, how it uses what it knows, and how fast it can know something new! (Prusak, 1996, p. 6)

It is important to set the competitive circumstances within which we study processes leading to strategic foresight. Good strategy is no longer just picking the right industry; it is being at the right place in the industry – at the cutting edge of industry evolution – new technology, new markets, new moves by competitors. For firms in high-velocity environments (Eisenhardt, 1989), emphasis needs to shift from the competitive dynamics of industry selection and interfirm competition to intrafirm rates of change (McKelvey, 1997). As high-velocity product life cycles and hypercompetition have increased (D'Aveni, 1994), speed of knowledge appreciation has become a central attribute of competitive advantage (Leonard-Barton, 1995), as has organizational learning (Barney, 1991; Argote, 1999). Seeing industry trends (Hamel and Prahalad, 1994) and staying ahead of value migration (Slywotsky, 1996) are also valued. Porter (1996) emphasizes staying ahead of the efficiency curve. Dynamic ill-structured environments and learning opportunities become the basis of competitive advantage if firms can be *early* in their industry to unravel the evolving conditions (Stacey, 1995).

Much of the concern about human capital appreciation bears on high-technology-based industries (Leonard-Barton, 1995). Eisenhardt and colleagues have focused on 'high-velocity' high-tech firms for some time (Eisenhardt, 1989; Eisenhardt and Tabrizi, 1995). In these firms the classic 'organic' organizing style is just too slow to keep pace with changes in high-velocity firms (Brown and Eisenhardt, 1997). In the 21st-century knowledge economy the main danger comes from viscous information flow. Firms need to learn how to speed up knowledge flow (Boisot, 1998). Given high-velocity environments, Hamel and Prahalad (1994) view foresight as seeing economic rents stemming from learning about industry trends before competitors, and imposing 'stretch'. Later we shall equate stretch with the energy differentials of the Bénard (1901) process, and generalize it into 'adaptive tensions' (McKelvey, 2001, 2008). These are defined as imposing contextual tensions strong enough to stimulate discontinuous or 'punctuated' adaptive change within a firm (Tushman and Romanelli, 1985; McKelvey, 1994).

Slywotsky (1996), studying value migration, ostensibly focuses on strategy as a chess game, complete with chess-like patterns managers need to know about. Underlying this, however, he actually tells foresight managers to do the kinds of analysis that uncover *how* customers go about discovering what their needs and priorities are – if you know their prioritizing process, you can uncover their priorities as soon or sooner than they do. Collins and Porras (1994) and O'Reilly and Pfeffer (2000) focus on the core ideologies underlying the foresight management processes that allow some firms to constantly get to new ideas and products before their competitors.

Starting from scientific realism's transcendental causality, our theory about the strategy-finding process stresses the use of (i) *far*sight – pattern processing to simplify and focus information about a firm's environmental context so as to get a grip on where to look, and (ii) *fast*sight – emergent complexity to create and energize the kinds of social networks within a target firm so as to improve its external seeing ability and get a grip on who looks and how quickly. We use complexity science as the analytical engine to unravel both far- and fastsight dynamics. For reasons of exposition, we discuss the farsight process first and then fastsight.

For the 'where to look' question, we turn to the study of longer-run, extant trends at the level above a firm-in-an-industry plane of observation to unravel the firm's environmental context and its potentially dominating adaptive tensions – the supra-forces. We use complexity science to develop a search procedure whereby a firm can process the myriad patterns to simplify down to the more accurate and significant patterns. We do so by focusing on pattern formation and simplification, order parameters, and order creation theory, bringing adaptive tension into greater detail in the process. Here, complexity science is the engine for improving *far*sight.

For the 'who looks' part, we focus on the social network processes comprising distributed intelligence. Especially, we study how to speed up the functioning of the corporate brain and how to sharpen its 'seeing' ability. We use complexity science as it bears on critical values and phase transition effects caused by adaptive tensions (energy differentials) to initiate self-organizing activity aimed at speeding up collective search behaviors. These sub-force dynamics lead to fastsight. Here, complexity science is the engine for improving *fast*sight ability.

This pattern-search, *far*sight procedure, however, requires a well-functioning social network 'seeing' device to deal with the 'who looks' and 'how fast' questions. In a recursive fashion, analyses of where a firm stands with respect to the broader adaptive tensions provides information that can be used to both motivate and steer phase transitions, coevolutionary events, and social networks' self-organizing behaviors. In short, farsight delineation of adaptive tensions motivates self-organization by social networks – improving their fastsight capability. Fastsight development by social networks, in turn, leads to better farsight seeing ability. Why? Broad trends decompose into higher frequency event horizons as one drops down levels of analysis (Simon, 1999) and the events come closer to having impact on a firm. Fastsight becomes a crucial element of farsight as broad, seemingly slow-moving patterns resolve into higher-speed dynamics. Bottom line? Supra-forces and sub-forces coevolve to improve strategic far- and fastsight. Needless to say, reliance on a single visionary CEO is totally inadequate (Marion and Uhl-Bien, 2001; Uhl-Bien et al., 2007).

Defining transcendental foresight

> Alfred North Whitehead gives us a fairly elaborate definition of foresight: 'the ability to see through the apparent confusion, to spot developments before they become trends, to see patterns before they fully emerge, and to grasp the relevant features of social currents that are

> likely to shape the direction of future events' and being able to 'look for generality where there is variety, and to 'look for idiosyncrasy where there is generality' (1967, p. 89).

However, the word is a tricky one coming with some hidden baggage. Webster's Dictionary gives the preferred meaning of foresight as 'prescience', defined as: 'foreknowledge of events; a: divine omniscience; b: human anticipation of the course of events'. This view of foresight presages the currently popular concept of the charismatic *visionary* leader (Bennis, 1996; Bryman, 1996) who leads by having a good vision of the future. This orientation toward 'foresight' seems to date back to the days of witch doctoring, and the Oracle at Delphi – some people apparently can see into the future. Strategic thinking is better served by taking a lesson from drunk drivers – the more they drink the slower their brain responds to 'seeing' an approaching curve and, worse, they do not see the curve until they are closer to it than when they are sober. We shall argue that advantageous strategic foresight is better defined as comprising both fast- and farsight.

This chapter is also about 'transcendental foresight'. It builds on the 'transcendental realism' of Roy Bhaskar (1975), one of the founders of modern scientific realist philosophy of science. Foresight is about peering into the future to discern which events are likely to cause other events. By using the term 'transcendental', Bhaskar simply reminds us that causality stems from forces operating at levels different from the plane of our directly observable experience. Given Porter's (1980) characterization of the observable plane of industry competition as consisting of the 'five forces', transcendental foresight calls for focusing on 'sub-forces' and 'supra-forces'.

There are three paths to the future – ordered by foresight feasibility:

1. *Path 1*: Yes, the future – that hasn't happened yet – is uncertain and unknowable, but from the perspective of any given observer, much of what appears to be 'an uncertain future' has already happened and is 'uncertain' only because the observer is lacking information. In this view, foresight is simply learning about the knowable part of what, to the less perspicacious, appears uncertain. No smoke and mirrors here; it is simply a matter of getting out there and studying what has happened before competitors do so. Porter's 'competitive intelligence' fits here – learning about industry-driver effects (already in place) before one's competition.
2. *Path 2*: To the perspicacious, future events are dimly indicated by developments that will become trends and by dots that once filled in will become patterns already in place. This is a sort of pre-trend and pre-pattern view. This presumes a linear, unbroken predictability – the faint glimmerings that we discern now will eventually unfold, as buds slowly turn into flowers. This view assumes that the more perspicacious see the unfolding future sooner than their competitors. This view is closer to the 'let history predict the future' view than one might like to think. Except that instead of from past-to-present it is present-into-the-future. The presumption of the underlying dynamic is the same – linear predictability. This is what econometricians do – make inferences about the future from analyses of the past.
3. *Path 3*: The future is fraught with discontinuities, suggesting that what lies before a discontinuity offers little insight as to what lies beyond. This is the view of chaos and complexity theorists. They see a world of aperiodic, nonlinear, coevolutionary,

discontinuous events. Patterns here do not appear to emerge from historical trends; these cannot be inferentially derived or extended into the future.

We elaborate on fastsight to speed up progress along the second path. We elaborate on farsight to see emerging patterns lying behind the emerging discontinuities of the third path. Complexity science informs both elaborations.

Bhaskar, explanation, and the plane of observation
Bhaskar's transcendental realism is the understructure supporting our notion of transcendental foresight. Bhaskar makes a clear distinction between developing theory based on identified *regularities* – which could be accidental – and experimentally contrived *invariances* in which repeated experiments produce an outcome regularity by manipulating what is hypothesized to be an underlying force, process, mechanism, or structure. Contrived invariances better fit the counterfactual conditional basis of lawlike statements about generative forces that might seldom if ever be naturally discernible in complex open systems (such as organizations) because of the many countervailing influences. Initially, the mental models of idealists and realists both contain 'imagined' (Bhaskar's term, p. 145) conceptual, intangible, unmeasurable theory terms. The difference is that for idealists they remain forever intangible, interpreted, socially constructed, metaphysical, and *unreal*, whereas for realists the better detection of theoretical terms, repeated experiments, and other kinds of empirical research eventually give reason to believe that what were initially imagined metaphysical terms and entities become *real*. Bhaskar notes, however, that the world becomes a construction of the human mind and of a scientific community (pp. 22–7, 148–67). He says:

> [Transcendental realists regard] objects of knowledge [in the models] as the structures and mechanisms that generate phenomena; and the knowledge as produced in the social activity of science. These objects are neither phenomena (empiricism) nor human constructs imposed upon the phenomena (idealism), but real structures which endure and operate independently of our knowledge, our experience and the conditions which allow us access to them. Against empiricism the objects of knowledge are structures, not events; against idealism, they are intransitive . . . (p. 25)

Bhaskar (p. 25) takes an 'updated dynamized' version of Kant's famous transcendental argument that reason and experience presume a priori objectively valid phenomena (Audi, 1995, p. 808). '[I]ntransitive objects of knowledge are in general invariant to our knowledge of them: they are the real things and structures, mechanisms and processes, events and possibilities of the world' (Bhaskar, p. 22). 'Intransitive' means that objects of scientific discovery exist independently of human perceptions, interpretations, and social constructions, and by 'structured', Bhaskar means they are 'distinct from the patterns of events that occur' (p. 35). 'Generating structures' are underlying forces that may occur independent of observed regularities and may not be observable or measurable except via contrived experiments and the creation of invariances.

In this 'transcendental' view, true explanation comes from above or below the plane of direct human observation. To pick a simple example, consider a pot of water coming to the boil on a stove. What we see at the plane of observation is the fire, the pot of water, and the beginning of emergent steam from its spout. What we do not see are the causes (outside the pot) of why the fire occurred and is hot and (inside the pot) why the molecules, as agents,[1] change their governing rules as they go, from (i) mild heat and increased vibration while maintaining position; to (ii) the rolling boil in which they move around in the pot; and finally to (iii) emerging from the pot as steam. It seems logical to us that attempts at gaining foresight should be rooted in philosophical views as to how changing phenomena are best explained – presumably by truthful theories.

Echoing Bhaskar, Salthe (1985) devotes an entire book to his argument that all of science focuses explanation around a 'triadic' structure. A firm ('system') exists in a hierarchy in which there are both upper- and lower-level constraints – environmental 'context' and intrafirm 'agents', as we use these terms in this chapter. Salthe might well have drawn on Bhaskar's (1975) classic discussion of transcendental realism.

Focus on transcendental forces

The term, foresight, obviously, has two parts, 'fore' and 'sight'. We detailed three variants of the 'fore' part above, saying we were going to focus on the second and third variants. We reject the idea of divine omniscience or humans being able to see the future. But strategists can try to look farther down the road faster than competitors and we academics need to offer new ideas that help strategists see beyond the next discontinuity in their competitive landscape.

Besides the feasibility triad, the 'fore' part also subdivides into three levels of 'seeing'. For purposes of exposition, we shall take the 'firm-in-its-industry' level as the plane of observation. Porter's (1980) competitive strategy and its emphasis on the five forces of industry competition is our exemplar. For many people, foresight is nothing other than trying to figure out what the future effects of the five forces are likely to be. The population ecology movement in the study of organizations (Hannan and Freeman, 1989) is another example of attention to the industry (population) plane of observation. Following Salthe and Bhaskar, however, the industry-level plane of observation is the set of top-management agents operating *between* forces above and below their plane of observation – the environmental context *above* the industry plane and coevolving lower-level agents *below*. Building on Porter's language, elements in the environmental context become the *supra-forces* and coevolving agents within a firm become the *sub-forces*. One of the reasons why Hamel and Prahalad's book, *Competing for the Future* (1994), has had such an impact is that it bases its notions of foresight on *both* the supra- and sub-forces. Thus, on the one hand they say, 'Industry foresight must be informed by deep insight into trends in lifestyles, technology, demographics, and geopolitics' (p. 89) – a supra-force orientation. But on the other, they focus on core competencies of the agents within firms (Ch. 10) – a sub-force orientation. We use elements of complexity science to expand on Hamel and Prahalad's 'transcendental' insights.

Far*sight* Neoclassical economists view the world as composed of long periods of equilibrium separated by momentary (inconvenient) periods of discontinuous new order creation (Hinterberger, 1994; Rosenberg, 1994), and have patterned their view of good science after that of classical physics (Mirowski, 1989). Their use of linear differential mathematical models has seeped into other social sciences (Henrickson and McKelvey, 2002). The equilibrium assumption allows them to focus on instrumentally predictive variables (Friedman, 1953).

Physics-oriented complexity scientists, in contrast, see order creation in the world as mostly the result of nonlinearities separated by occasional periods of equilibrium. Some complexity scientists focus on nonlinearities resulting from energy differentials (Prigogine, 1955, 1997; Cramer, 1993) and phase transitions (Lorenz, 1963; Haken, 1983). Others, starting from quantum theory, focus on how order emerges from randomness (Gell-Mann, 1988, 2002; Mainzer, 1994/2004). Haken (1983) begins a theory about how order parameters emerge. We elaborate on this stream of complexity theory to develop a theory of pattern formation and then we use the same theory to develop a farsight search process.

Fast*sight* The 'sight' part raises the question: 'sight' by whom? Henry Ford[2] is notorious for asking, 'Why is it that whenever I ask for a pair of hands, a brain comes attached?'. In this view, foresight is only possible by the person, or perhaps a few people, at the very top of firms. Leadership gurus such as Bennis (1996), focusing on charismatic visionary leaders, make the same mistake (Uhl-Bien et al., 2007). Since Ford's time, economics has been broadened to include human capital throughout a firm (Becker, 1975) and the social capital that interconnects human capital (Burt, 1992). Even more recently attention has focused on distributed knowledge management (Davenport, 1997), distributed organizational learning (Argote, 1999), and distributed intelligence (McKelvey, 2001, 2008; Stacey, 2001). Distributed intelligence rests on distributed information input, that is, 'distributed seeing'. We use the latter as the technology for speeding up foresight so as to get *fast*sight.

Astronomers use the 'VLA' (Very Large Array) observation system in New Mexico where, instead of one single localized lens (the visionary CEO version), 27 radio telescopes, each movable over a wide geographical area, are distributed so as to maximally 'see' and collect a radio signal coming from some distant quasar – equivalent to a single lens 22 miles across! They get a tremendous advantage from 'distributed seeing'. How to make distributed seeing work better in organizations? Can a CEO produce strategically useful, distributed seeing in a world of nonlinear discontinuities?

Key questions are: who is looking? How many are looking? How hard are they looking? What are they looking at? Therefore, a study of the strategic foresight process needs to pay as much attention to who is doing the looking and how to manage it, as it does to what they are looking at or looking for. The idea that fastsight comes only from the few people at the top is surely archaic. Given the importance of gaining more fastsight than one's competitors (Hamel and Prahalad, 1994), we begin by outlining some ideas about how to better develop and manage 'distributed seeing' – the 'who is looking' and 'how do they do it collectively' part. For this, we draw on mostly biological and social scientists connected with the Santa Fe Institute – Arthur (1988, 1990); Holland (1988), Kauffman (1988, 1993, 2000) among many others – who see agent coevolution as the primary source of nonlinearities. Unlike classical physicists and neoclassical economists, who assume that agents are homogenous because the math works better, the Santa Fe scholars assume that agents are heterogeneous (Kauffman, 1993; Holland, 1995; Epstein and Axtell, 1996), and use agent-based computational models rather than math models (Casti, 1997; Henrickson and McKelvey, 2002).

Integrating fast- *and* far*sight* What is most interesting about lessons we draw from complexity theory is that fast- and farsight go hand in hand. Farsight calls for better understanding of the broadest tensions – the supra-forces – imposing on a firm's competitive landscape. Farsight tensions also serve as the adaptive tensions that energize coevolving agents in connectionist networks. This leads the network to function better, leads to distributed intelligence, and sharpens the network's ability to improve its pattern processing capability and, consequently, find patterns faster. This leads to fastsight. But, broad tensions decompose into higher-frequency (faster-moving), more specific tensions as levels of analyses drop (Simon, 1999), and their effects come to have more obvious near-term likelihood of creating discontinuities. When this happens, firms that are prepared with fastsight capability win. Better network functioning – the sub-forces – therefore, improves farsight responsiveness. Farsight and fastsight, therefore, are recursive dynamics. This will become clear as we proceed. Farsight is about finding the right pattern. Fastsight is about finding it in timely fashion. Both are preconditions of effective adaptation.

Translating to transcendental complexity: Ashby's law

In his classic work, *An Introduction to Cybernetics*, Ashby (1956) says:

> When a constraint exists advantage can usually be taken of it . . . Every law of nature is a constraint . . . Science looks for laws . . . Constraints are exceedingly common in the world around us . . . A world without constraints would be totally chaotic . . . That something is predictable implies that there exists a constraint . . . Learning is worth while only when the environment shows constraint. (pp. 130–34)

He also notes that order (organization) exists between two entities, *A* and *B*, only if the link is 'conditioned' by a third entity, *C* (1962, p. 255). If *C* symbolizes the 'environment', which is external to the relation between *A* and *B*, environmental constraints are what cause order (Ashby, 1956). This, then, gives rise to his famous Law of Requisite Variety: 'ONLY VARIETY CAN DESTROY VARIETY' (p. 207; his capitals). It holds that for a biological or social entity to be efficaciously adaptive, the variety of its internal order must match the variety of the environmental constraints.

If Ashby were writing now he would surely update his Law, as follows:

Only variety can destroy variety.
Only degrees of freedom can destroy degrees of freedom.
Only internal complexity can destroy external complexity.

This rephrasing rests on the widely held view that complexity is a function of degrees of freedom.

The first lesson from Ashby is that for strategists to find emerging patterns in what appear to be chaotic environments, they need to uncover the contextual constraints and resources. The second lesson is that internal complexity needs to match the complexity of the environmental context. A third, related lesson comes from Allen (2001). Since it is impossible to know in advance which of a firm's degrees of freedom will actually be relevant to a particular environment, Allen proposes his Law of Excess Variety. A firm cannot simply create internal variety to *match* the environment. It has to create *excess* variety. It follows that a pattern-finding social network within a firm has to be more complex than the complexity of its competitive environment!

Summary
In this section, we drew on Bhaskar's (1975) transcendental realism to define 'transcendental foresight'. Taking a 'firm-in-an-industry' as the plane of observation, we then defined *far*sight as calling for an appreciation of the complexity dynamics in the firm's environment and *fast*sight as calling for distributed seeing within the firm. We then drew on, and updated, Ashby's (1956) Law of Requisite Variety to argue that the complexity of distributed seeing capabilities within the firm have to match the requisite complexity of the firms external competitive environment.

Managing *far*sight dynamics via the supra-forces
We begin by defining forces above the plane of observation and then turn our discussion to how to simplify the quadrillions of impinging patterns.

Supra-forces
To get an idea of what we mean by a firm's supra-forces, about what kind of farsight is desired, we begin with a biological analogy. Consider a species (population) coevolving in some niche along with other competing populations. This is the plane of observation – the level equivalent to Porter's five industry-level forces. What are the forces most crucial to the survival of a niche or most likely to change it? To see these we need to look beyond Darwinian selection processes (Box 1.1).

BOX 1.1 FORCES UNDERLYING BIOLOGICAL DIVERSITY

Lava plumes, plate tectonics, plate subduction
Rising and falling continents
Volcanoes, smoke and ash, and mountains
Emergent rivers, lakes, ponds, and oceans
Climate zones
Emergent forests, plains, deserts, climate zones

These are the supra-forces of biological diversity and speciation that give rise to the 'punctuated equilibrium' of Eldredge and Gould (1972). They argue that these are the forces serving to explain the gaps in the fossil record. If one speeds up a 'movie' of the past 3.8 billion years of life on earth (McKelvey, 2004b), one sees that it is the self-organization of biological agents in the face of the forces mentioned in the box. The plane of analysis has been shifted from local coevolutionary niche dynamics to geological forces.

With this lesson in mind, consider some of the analogous supra-forces for firms (Box 1.2).

Of course, many of these are very broad trends, primarily in the future, and quite unresolved as to their near-term business implications. On the other hand, the 'terrorism trend' has resolved very quickly after the 9/11 World Trade Center attack (Suder, 2006). Many businesses have figured out that there are many fall-outs from this, security, encryption, and protection against weapons of mass destruction being the most obvious. Presumably, each one of the foregoing broad trends will, at some point, resolve just as the terrorist trend recently has. More generally, to the discerning eye, each trend may

BOX 1.2 ANALOGOUS SUPRA-FORCES FOR FIRMS

Basic research and new knowledge
Basic science activities and findings
Cues about trends and implications of basic science developments
Technology and knowledge applications
Petroleum depletion
Global resource depletion
Global warming
Demography
Globalization
Multicultural
Japan/Europe economic time-bomb – low birthrate and low immigration; which leads to lower tax base; compounded by increasing pension costs
Poverty: G7 and vs. Third-World hunger
Third-World education
Effects of Third-World economic development
Global and local politics
Small wars here and there
China, India, Russia, Iraq, Iran, North Korea
Changes in economic regimes
Islam and/or terrorism
Third-World nuclear threats

be understood as containing a cascade of more specific, narrow foresight possibilities. Simon (1999) points out that in both natural and social science, as the broad is decomposed into the specific, and the high level decomposed to the low level, the frequency rate increases. Going down almost any hierarchy, what starts as *far*sight eventually calls for *fast*sight! All of these tensions currently impose on some sectors of the world's economies. Entrepreneurship and order creation are nothing more than decomposing these broad tensions down to specific, near-term business opportunities. Each of the broad trends, as they resolve, also can be further subdivided into fast- and farsight-based implications for marketing, production, research and development (R&D), and finance. Boisot and McKelvey (2006a,b) focus on the problem of speeding up fastsight to the point where strategists can see patterns forming – tracks in the sand – that give early clues about forthcoming extreme events like the 9/11 disaster or the London and Madrid bombings before they happen.

There are other hierarchical implications. One can also refine the broad trends into implications for firms at various levels of the SIC code. Thus, perhaps only the largest (2-digit) 'food-production' firms can, at this time finance the technological R&D implications and subsequent organizational implications of, say, demographic and world-hunger-related trends. But, as Slywotsky (1996) observes, firms can gain much insight into the future by trying to anticipate how their customer firms are, in turn, going to respond to their customers' needs. Thus, near-term business opportunities for 'supplier' firms resolve from an understanding of how larger firms are trying to anticipate solutions to the broader, long-term trends. It follows that the resolution of one broad trend, say terrorism or hunger, growth in China's economy, Islam's various effects, and so on, resolves into implications for other broad trends such as R&D and technology development, and from there into decomposed, narrower, near-term business opportunities. What should worry any CEO is the prospect that new order-creation discontinuities are in the making at all times – as opportunities for competitors, or problems and opportunities for one's own firm.

Surely useful foresight starts with understanding the long-term effects of these forces on one's firm. Who best to imagine possible outcomes of these forces? This is where the power of distributed seeing comes to play. Presumably, the many lower-level (sub-force) agents have a higher collective probability of seeing these forces and having the intelligence (ideas) to create ideas about how to respond. But, if they look in too many places all at the same time, their seeing ability is out of focus and apt to yield poor results. This is why Hamel and Prahalad (1989) suggest 'refining strategic intent'.

But, what does 'refining strategic intent' mean? By our analysis, long-term trends set in motion broad kinds of pattern formation. These decompose into near-term patterns that become near-term business opportunities. Which competitors see the latter first? Complexity scientists argue that complexity dynamics drive long-term pattern formation and the discontinuities involved. We theorize below that it takes complexity dynamics to unravel patterns set in motion by complexity dynamics. In order for internal connectionist networks to be effective at unravelling external complexity dynamics, they need a search procedure that is, itself, informed by complexity dynamics. We discuss this next.

Pattern-creation theory from complexity science

In defining variety, Ashby (1956, pp. 124–5) pointed to the following series: '*c*, *b*, *c*, *a*, *c*, *c*, *a*, *b*, *c*, *b*, *b*, *a*'. He observed that *a*, *b*, and *c* repeat, meaning that there are only three '*distinct* elements' (original italics) – three kinds of variety or three degrees of freedom. In the language of patterns, however, this is variety at the level of 'dots'. Suppose, instead, we define variety in terms of the number of patterns instead of the number of dots. Then, using the formulae from Table 1.1, we see that four dots lead to six possible links; they also generate 64 possible patterns. With 10 dots one gets 45 possible links and approximately 35 trillion possible patterns. Ashby's 12 'variety' dots produce 66 possible links and approximately 4,700 quadrillion possible patterns! Even supposing that 99 percent of these are not worth paying attention to, trillions are left, and one still does not know, up front, which ones are trivial and which are not.

Despite this computational reality, six of America's most experienced intelligence practitioners, writing in *The Economist* (2003, p. 30), about the FBI's failure to 'see' the terrorists' networks (patterns) before the 9/11 event, argue that although there had been 'an inability to connect the dots', what is really needed are more useful dots to connect,

Table 1.1 Relation of dots to patterns

Number of dots: N	Number of possible links: $L = N(N - 1)/2$	Number of possible patterns: P = 2L
$N = 4$	$L = 6$	$P = 64$
$N = 10$	$L = 45$	P = 35 trillion
$N = 12$	$L = 66$	P = 4,700 quadrillion

more fine-grained and better-quality data, and more monitoring based on the data. We believe, however, that foresight does not come from simply pleading for more and better dots. This is to greatly mistake the nature of the problem. An arithmetic increase in the number of 'dots' – high quality or otherwise – leads to a geometric increase in the possible connections that one can establish between them. It also leads to an exponential increase in the number of patterns to decipher.

In quantum-theory language, Gell-Mann (1994, Ch. 11) refers to the trillions of possible patterns among the 12 dots as the 'fine-scale structure'. There are so many interacting correlations among the dots that discernible effects are 'washed out'. His quantum theory focuses on what he calls the 'coarse-graining' process whereby the few dominant patterns that one needs to know about emerge out of the fine-scale structure. He points to the effects of 'context' as causes of coarse-graining.

Haken (1983) takes a closer look at the process by which contextual tensions produce coarse-graining of one kind as opposed to all sorts of other kinds, given the trillions of possible patterns 'out there'. He shows how some contextual elements become the 'order parameters' that drive the formation of new pattern formation – that is, new order. Mainzer ([1994] 2007), then, details how the many possible adaptive tensions, such as all those we listed earlier and many more, are reduced to the very few order parameters that actually drive new pattern formation at some given point in time.

Haken begins by describing a number of physical systems in which a critical temperature, T_c, causes a phase transition: magnetization, Bénard cells, lasers, cell formation in slime molds, chemical reactions such as Belousov–Zhabotinsky, predator/prey growth and decline rates, and so on. The most obvious one for most of us – especially cooks – is the temperature at which a rolling boil begins in a pot of water, that is, when water molecules change their 'rules' so as to transmit heat by moving around the pot rather than increased vibration in a stationary position. Haken is interested in trying to predict how agents – whether atoms, organisms, or social actors – self-organize into some specific pattern when the imposed external energy source exceeds R_{c1} – the 'first critical value' (which we discuss further in more detail in the fastsight section). R_{c1} triggers a phase transition at which point new structure and processes occur in physical systems such as those Haken points to. In Haken's view (1983, pp. 14, 195–9, 249–50), as the environmental energy gradient or adaptive tension approaches R_{c1}, changing external degrees of freedom *enslave* internal degrees of freedom that below R_{c1} were previously independent. As the phase transition completes, the dominant degrees of freedom – what he terms 'order parameters' – essentially negate all of the other degrees of freedom by reducing their relative importance, leaving only one (or a few) remaining as order parameters to define new pattern formation.

Mainzer (1994, pp. 66–8) – reinterpreting Haken considerably – sets the stage for a theory of order creation that builds from Ashby, Gell-Mann, and Haken. We elaborate on Mainzer's basic ideas in the following points to begin an integrative theory of how the more crucial coarse-grained patterns emerge from the fine-scale structure in the domains of physics and biology (we translate into the world of firms later):

1. Start with an existing coarse-grained system. Presumably its internal variety matches external environmental variety, such that each internal degree of freedom corresponds to an external one – otherwise it would not exist (not necessarily true of firms).

External degrees of freedom are uncorrelated, even chaotic, otherwise they would not exist as independent degrees of freedom.
2. As the one external energy gradient or adaptive tension (degree of freedom; Haken's 'mode') increases toward R_{c1}, adjacent external degrees of freedom recede in *relative* strength, that is, recede back into the fine-grained structure – which is to say their effect becomes randomized or washed out relative to the more dominant mode, and results in environmental effects that are increasingly chaotic – except for the one increasingly dominant mode (force or constraint). Thus, just before a tension parameter increases to the level of R_{c1}, chaotic environmental forces increasingly appear along with the dominant, stable mode.
3. As the *unstable* external forces multiply, they begin to enslave many of the stable internal degrees of freedom which they influence, thus eliminating the latter as meaningful forces. Consequently, the basis of coarse-graining is increasingly narrowed down to the dominant stable mode. Environmental chaotic-variety produces internal chaotic-variety – that is, fine-grained structure.
4. At the same time, the more dominant degrees of freedom associated with the imposed adaptive tension are also enslaving some internal degrees of freedom.
5. The unstable internal degrees of freedom disappear into a stochastic pool of Brownian motion. This leads to a vast reduction in degrees of freedom. Mostly, fine-grained structure dominates.
6. The last few stable vectors remaining, however, become Haken's 'order parameters', acting to create the emergent patterns of new order as the system tips over R_{c1} into the region of emergent complexity – meaning that the order parameters surviving across the phase transition are totally the result of the dominant mode(s) in combination with the surrounding fine-grained structure. These order parameters become Gell-Mann's contextual effects.
7. At this juncture, order, complexity, and increased degrees of freedom emerge. The result is emergent coarse-graining.
8. The region of emergent complexity persists until the energy differential is reduced by virtue of the continuing emergence of new structures – Prigogine (1955) calls them energy 'dissipative structures'. That is, coarse-graining continues until the energy differential is reduced. Of course, if the energy differential is continuously renewed equal to, or even faster than the existing new structures can reduce it, more dissipative structures will continue to emerge.

Needless to say, the foregoing is a very basic pattern formation theory from physics. Still, there are applicable organizational lessons for us:

1. We need to watch for tension parameters approaching R_{c1}. Even though the broad parameters we listed earlier may not appear to be approaching R_{c1}, quite possibly decomposed elements may be.
2. For any firm, at any given time, a very few, if not just one, tension parameter will become the order parameter – the basis of an emerging strategic intent.
3. To find the relevant emerging patterns, a firm has to zero in on the order parameters and decompose broadly defined ones into sub-parameters that have more near-term relevance.

4. The complexity elements we just used to theorize about new order creation are also the basis for suggesting a search procedure for how intrafirm social networks may go about uncovering the more worrisome or entrepreneurially relevant (sub-)order parameters (more on this in the fastsight section).
5. Our theory of how order parameters appear and how they cause pattern formation becomes our theory about pattern-search processes.

You can try this out in your next faculty meeting. Suppose each person is richly described by 100 variables and has correlated histories with 50 faculty members attending. Given all these variables and all-possible correlated histories, without any task, any probability of predicting a person's behavior would be nil – this is the fine-grained structure. But, add a context – such as 'we are going to vote on hiring person X as a faculty member' – and you can probably predict what most of your colleagues will say! Contextually driven tasks cause coarse-graining to take place.

In the next subsection we detail how our pattern-formation theory translates into a pattern-search theory.

Pattern finding via simplification

As an example to work with, suppose we start with the recent trend of increased consolidation in the telecom and entertainment industries (TE). Chandler's (1962) research on industry formation, combined with Williamson's (1975) transaction cost theory, leads us to expect vertical integration at the beginning of a new industrial era – in this case, one based on emergent fiber optic technology. But as an industry matures and fair markets begin to prevail, Williamson predicts that firms will divest subunits acquired early on so that they can 'buy at the market' rather than administer internal pricing. Here is a broad trend that has not even begun yet. Still, we can imagine the set of agents connected with competitors, technologies, markets, and other institutions as nodes on a search grid, interconnected by links. We know that even for just 10 such agents there are more than 35 trillion possible human capital interaction patterns that could materialize into specific business opportunities or threats. The problem is one of sifting through an overwhelming number of interactions and consequent pattern possibilities. Over time they produce countless correlated histories. In Gell-Mann's terms, this is the fine-grained structure. Is there a way to get some clues about how, where, and when coarse-graining will occur?

Now we take up the problem of how to conduct a search process that works toward uncovering potential order parameters? This calls for thinking of a pattern emerging in a five-dimensional array instead of in a set of lines on paper or in a photo. Our array is $\boldsymbol{i}^2$ TE agents by $\boldsymbol{k}$ tensions, $\boldsymbol{v}$ vantage points, and $\boldsymbol{t}$ time periods. We begin with the $\boldsymbol{i}^2$ component.

Defining the i^2 *agent set* Since our pattern is not known, we started by asking where does a pattern come from – in the previous subsection – as a way of developing a search procedure that might help our connectionist social network find it sooner rather than later. Let us suppose that our TE agents are scattered over a search space we define as an i 2 array – each of the i agents can communicate with each of the i – 1 other agents (they may or not all be in one firm). At a bare minimum, distributed seeing is a function of some number of connections among some set of the agents in the i 2 array. Each agent represents some player in the TE arena who could link with some number of other TE players. This linking activity is what could turn into a pattern of emergent social ordering, for example, a new combination of agents working toward a new technology or market approach. In a sea of agents, as the connections increase, a pattern may emerge and become discernible. But, as we saw earlier, there could be many agents and hundreds of connections among them. In this case, there could be quadrillions of patterns to sift through. How to simplify and speed up the search activity?

To begin, part of what the human cellular network inside a firm has to do is define the $\boldsymbol{i}^2$ array of TE players. Defining an optimal array may be difficult. Presumably, one can begin with a broadly agreed-upon core set of agents and then elaborate as seems appropriate. We could begin by selecting the most innovative agents from the most innovative firms along with possible university-based TE technology and market researchers. A key limitation in a situation of emergent-pattern finding is that parts of, or the entire pattern, may be 'outside the box' of the easily recognized players. Much of this has to do with defining the adaptive tensions that may become the order parameters. The well-known scenario planning process could be one way to do this – it could shift links and nodes from the 'plausible' to the 'possible'. Fortunately, there are ways to expedite this, which we discuss next. We do not mean to discount the difficulty of defining the $\boldsymbol{i}^2$ array, but we do believe that a well-working cellular network can do this; we pursue this latter point in the fastsight section.

Defining the k *adaptive tensions (potential order parameters)* In the framework of Darwinian selectionist evolutionary theory, the relevant interaction patterns of organisms cannot be defined without understanding the variables defining a system's environmental context – that is, the resources that a better-adapted system could gain access to and the various constraints that might inhibit successful adaptation. One way to narrow the elements of environmental context that are most apt to define the order parameters is to focus on those resources and constraints creating the most adaptive tension. To get a long lead in biology, we would study the geological trends mentioned earlier.

We take a cue from what McKelvey (2004b) calls the '0th law of thermodynamics'. This is a law about where order comes from, that is, what causes new order to appear. We have outlined some of the most basic elements of this law via the previous eight points defining the process by which the many contextual tensions reduce down to one or a few of Haken's order parameters. In the natural world, new order begins with energy differentials of sufficient strength to cause phase transitions. McKelvey (2001, 2008) translates energy differentials as 'adaptive tension' when applied to social systems. Adaptive tension results when a system is at some state, x, and to be fully adapted to one or more environmental states, it needs to be in state, y. When the tension defined as $y – x$ exceeds some *critical value*, R_{c1}, a process of new order creation begins and the beginnings of the newly emerging pattern start to appear. Building on the 0th law, we anticipate that searching only where adaptive tensions above their critical values[3] impose upon the target system offers an effective method for reducing many, if not most, agent interactions to fine-grained structure – which can be ignored.

Adaptive tensions inducing learning, improved fitness or performance, innovation, and so on, activate agents to start the coevolution process leading to new order. In the TE system there could be any number of adaptive tensions stemming from its particular context. The tensions have to be high enough that they exceed the threshold gates of each of the many agents. If no agent is activated there cannot be an emergent social-structural pattern. Presumably, in a setting consisting of a list of known resources and constraints, those having the most existing or potential adaptive tension have the highest probability of becoming order parameters. This is to say, of the tensions that are rising toward R_{c1} the fastest are most likely to become order parameters. Tensions that (i) have the most impact on the TE sector; (ii) are least understood by TE agents; and (iii) or simply negate the relevance of other tensions for TE, also have high probability of becoming order parameters. The third kind have the effect of lowering the value of R_{c1} – they will activate agents at lower levels of tension. Each one could create tension high enough – that is, above R_{c1} – to activate some number of agents to begin the coevolutionary order-creation process. This results in $\boldsymbol{k}$ adaptive tensions.

The several contextual tensions parallel the roles of different kinds of telescopes or different colored lenses. Each tension could highlight some agent interactions, leaving most unrecognized. Each different kind of telescope highlights different parts of the spectrum. More specifically, for example, a red lens highlights red agents; a yellow lens highlights yellow agents; and so on. If five 'colors' of agents are imagined to be most important in defining the state space of an emergent phenomenon, the five relevant colored lenses could be used to highlight patterns among the relevant agents, leaving all other agents and patterns to be ignored. Pattern finding is only as good as 'seeing'. The different tensions, like different telescopes or different colored lenses, improve seeing ability. This particular seeing ability, then, begins to identify the order parameters, which, in turn, drive the coarse-graining process.

Defining the $\boldsymbol{k}$ tensions depends on the ability of the cellular network to 'see' relevant contexts and their embedded tensions. How to improve 'seeing?'. Members good at defining the agents most relevant to the $\boldsymbol{i}^2$ array may not be as competent as others in defining the contextual tensions. Presumably some members of the network would specialize on 'seeing' relevant contextual variables. Good seeing is also a function of vantage points.

Defining the v *vantage points* Part of the problem in seeing is that perception is often biased by the viewer's local situation, existing biases, and learned perspectives. Musicians see different things from physicists; Arabs see different things from Europeans and Americans; poor people see different things from rich ones; travelers see different things from those who do not travel; and so on. People caught up in existing patterns may not see new ones. The continuing availability of heterogeneous agents cannot be taken for granted. There are many forces in organizations that lead to 'groupthink' (Janis, 1972). The control systems that are so prevalent in organizations (Morgan, 1997; Jones, 2000) invariably damp out heterogeneity (March, 1991) and lower-level innovation, and self-organizing capability, as shown in Thomas et al. (2005).

If all the agents are the same, there is no advantage to networking (Holland, 1995). End of story! We cannot overstate the fact that the more that agents in the cellular network view the $\boldsymbol{i}^2 \times \boldsymbol{k}$ part of the array from different vantage points, the more likely they will see emerging patterns. Further, perspectives from different vantage points may lead to more realistic definitions of $\boldsymbol{i}$ and $\boldsymbol{k}$. This process is essentially a function of how heterogeneous the agents are. We know from biology that when there is very low diversity in a gene pool, the less adaptive a species is[4] – this shows up from inbred members of European monarchies to species such as the California condor or cheetah – all of which are on the edge of extinction. Recall that agent heterogeneity is a founding principle of agent-based computational models. Models by Johnson (2000), Allen (2001), and LeBaron (2002), for example, demonstrate that when agents become less heterogeneous, the systems in which they function lose adaptive capability. Recent research on the importance of biodiversity reported in *The Economist* (2006) supports this point as do two recent books: *The Wisdom of Crowds* (Surowiecki, 2004) and *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Page, 2007). Whereas agent-based model builders can assume agent heterogeneity simply from the process of randomly assigning fitness levels and capabilities, this is not so with human connectionist networks.

How many vantage points are necessary? If the *n*th vantage point to be added offers no new patterns, then no more are needed.

Defining the t *time periods* Given i 2 dots, k contexts and v vantage points, there could still be a large number of emergent-appearing patterns. An additional way of thinning the field is to look at patterns surviving across some number of time periods. Time periods also act like different colored lenses or different kinds of telescopes in offering different views of patterns. Patterns that appear robust in an early time period may disappear in later ones. Usually, patterns that persist across some number of time periods are the ones to pay attention to. Presumably a connectionist network would start with patterns remaining after the k and v processes have winnowed out many, if not most patterns. These patterns would be tested in as few subsequent periods as necessary to, well, see that the pattern holds up over time.

Summary

In this section we have explicitly used 'complexity to destroy complexity', taking a cue from Ashby's famous phrase, 'It takes variety to destroy variety'. We used complexity theory to outline how patterns form in a complex world. We then used the same theory to develop a farsight search process centered on the $\boldsymbol{i}^2$, by $\boldsymbol{k}$, $\boldsymbol{v}$, $\boldsymbol{t}$ array. In the next section we shall use the same complexity theory to show how contextual tensions motivate and steer the formation of a firm's distributed seeing via connectionist social networks, assuming that they are free enough from top-management control effects to actually form and become robust enough to take on the pattern-search process.

Managing fastsight dynamics via the sub-forces

> My work is in a building that houses three thousand people who are essentially the individual 'particles' of the 'brain' of an organization that consists of sixty thousand people worldwide. (Zohar, 1997, p. xv)

Zohar starts her book by quoting Andrew Stone, Director of the retailing giant, Marks and Spencer: each particle has some intellectual capability – Becker's 'human capital'. And some of them talk to each other – Burt's 'social capital'. But, together they comprise 'distributed intelligence'. Human capital is a property of individual employees. Taken to the extreme, even geniuses offer a firm only minimal adaptive capability if they are isolated from everyone else. A firm's core competencies, dynamic capabilities, and knowledge requisite for competitive advantage increasingly appear as *networks* of human capital holders. These knowledge networks also increasingly appear throughout firms rather than being narrowly confined to upper management (Norling, 1996). Employees are now responsible for adaptive capability rather than just being bodies to carry out orders. Here is where networks become critical. Much of the effectiveness and economic value of human capital held by individuals has been shown to be subject to the nature of the social networks in which the human agents are embedded (Granovetter, 1985; Nohria and Eccles, 1992; Burt, 1997).

Intelligence in brains rests entirely on the production of emergent networks among neurons – intelligence *is* the network (Fuster, 1995, p. 11). Neurons behave as simple 'threshold gates' that have one behavioral option – fire or not fire (p. 29). As intelligence increases, it is represented in the brain as *emergent* connections (synaptic links) among neurons. Human intelligence is 'distributed' across really dumb agents! In computer parallel-processing systems, computers play the role of neurons. They are more 'node based' than 'network based'. Artificial intelligence (AI) resides in the *intelligence capability* of the computers as agents, with emergent network-based intelligence rather primitive (Garzon, 1995). AI models increasingly are used to simulate learning processes in firms, though their intelligence capability is not fully connectionist and the intelligence of their agents is minimal – far below that, even, of PCs (Prietula et al., 1998). Our focus on distributed intelligence/seeing places most of the emphasis on the emergence of constructive connectionist networks. Of course, firms that have constructive networks among geniuses usually will fare better than those having great networks among idiots. The lesson from brains and computers is that organizational intelligence is best seen as 'distributed' and that increasing it depends on fostering network development along with increasing agents' human capital. Thus, 'Who is doing the looking?' is a function of the distributed intelligence and seeing capability of an organization. Distributed-seeing ability depends on how well the connectionist networks work. The better they work, the faster the seeing.

We cannot overemphasize our combining of human and social capital. Economists, stressing human capital, and focusing on neoclassical market concepts, assume that intelligence is only in the nodes and not in the emergent system. Sociologists, stressing social networks, assume that intelligence is in the network, and, further, that whatever capabilities nodes have result from their embeddedness in the network. We, along with complexity scientists, assume both: intelligence resides in the connectionist network *and* in its nodes as well.

Fastsight lessons from complexity science dynamics

How to speed up fastsight capability in a firm? How to get insights about a changing environment faster than the competition? How to improve the operating speed of emergent connectionist networks in firms that are playing the role of the astronomers' distributed seeing 'arrays' we mentioned earlier? How can complexity science help?

Complexity science defines the basic process by which connectionist networks form. Connectionist networks are the 'seeing' devices for complexity scientists. They appear most obviously as 'genetic algorithm' (Holland, 1975, 1995; Mitchell, 1996; Pal and Wang, 1996) and 'neural network' pattern recognition devices (Bishop, 1995; Bartlett and Anthony, 1999). Boisot and McKelvey (2006a,b) develop this technology into a basic approach for improving organizational pattern-recognition ability. They also focus on how to improve the speed at which pattern recognition can be accomplished.

Defining agent interaction and emergence dynamics For complexity theorists, connectionist networks act as the basic pattern-recognition devices in firms. The more complex the external environment, therefore, the more complex the internal network must be – the more complex pattern creation is on the outside, the more sophisticated pattern recognition must be on the inside. Thompson (1967) and charismatic vision leadership theorists (Bennis, 1996) put all the emphasis on top management as the preferred pattern-recognition device. Thompson's argument was that top management absorbed the uncertainty thereby creating predictable, machine-like conditions for lower-level employees to work in. Mélèse (1991) takes the opposite view, as we do here, which is that only a social network matching complexity with that of the environment can reasonably cope with incoming uncertainty. This follows from Ashby's law, which we mentioned earlier.

Holland (1988, p. 117–8) summarizes key elements of complex adaptive systems:

1. 'Dispersed Interaction' – dispersed, possibly heterogeneous, agents active in parallel;
2. 'No Global Controller or Cause' – *coevolution* of agent interactions;
3. 'Many Levels of Organization' – agents at lower levels create contexts at higher levels;
4. 'Continual Adaptation' – agents revise their adaptive behavior continually;
5. 'Perpetual Novelty' – by changing in ways that allow them to depend on new resources, agents coevolve with resource changes to occupy new habitats; and
6. 'Out-of-Equilibrium Dynamics' – economies operate *far from equilibrium*, meaning that economies are induced by the pressure of trade imbalances – individual-to-individual, firm-to-firm, country-to-country, and so on (headings in quotes are from Arthur, Durlauf and Lane, 1997, pp. 3–4).

'Emergent self-organization' begins when three elements are present: (i) heterogeneous agents; (ii) connections among the agents; and (iii) motive to connect – such as mating instincts, improved fitness, performance, and learning. Take any one away and nothing happens. Self-organization results in emergence, that is, new order of some kind. According to Holland (2002) we recognize emergent dynamics when we see multiple levels (hierarchy), intra- and inter-level causal dynamics, and nonlinearity.

We highlight two elements from the foregoing list in italics: 'coevolution' and 'far from equilibrium'. The coevolution term signifies a key nonlinear outcome for biologists and social scientists at the Santa Fe Institute. The 'far from equilibrium' phrase hooks these elements into physical scientists' interest in the triggering of phase transitions and consequent new structure and processes (Prigogine and Stengers, 1984). If the connectionist networks in firms do not have these characteristics, they are not going to serve as effective and timely pattern recognition devices. In short, fastsight depends on a firm having the foregoing network attributes. As you can see, the first critical value, R_{c1}, shows up in internal complexity dynamics as well.

Coevolution dynamics To understand how connectionist social networks self-organize to create (new pattern recognition) structures, Santa Fe complexity scientists focus on coevolution, nonlinearity, and small instigating events – Holland's (2002) 'levers'. Coevolution of heterogeneous, adaptive learning, agents is the 'engine' of order creation. What instigates bursts of nonlinear order creation via coevolution? Gleick (1987) details chaos theory, its focus on the so-called butterfly effect – a 'butterfly-lever', if you will – (the fabled story of a butterfly flapping its wings in Brazil causing a storm in Texas

(Lorenz, 1972)), and aperiodic behavior ever since the founding paper by Lorenz (1963). Arthur (1990, 2000) focuses on positive feedbacks stemming from levers. In the Santa Fe view, butterfly-levers initiate agent coevolution which results in social networks able to self-organize into kinds of connectionist networks capable of distributed seeing and pattern recognition (Boisot and McKelvey, 2006a,b).

In his classic paper, Maruyama (1963) discusses 'mutual causal' processes mostly with respect to biological coevolution. He also distinguishes between the 'deviation-counter-acting' *negative* feedback most familiar to general systems theorists (Buckley, 1968) and 'deviation-amplifying' *positive* feedback processes (Milsum, 1968). Negative feedback control systems such as thermostats are most familiar to us. Boulding (1968) and Arthur (1990, 2000) focus on 'positive feedbacks' in economies. Positive feedback effects emerge when a microphone is placed near a speaker, resulting in a high-pitched squeal. Mutual causal or coevolutionary processes are inherently nonlinear – large-scale effects may be instigated by very small initiating events, as noted by Gleick (1987), Ormerod (1998) and Holland (2002). McKelvey (2002) discusses the role of damping processes pertaining to coevolutionary behavior – coevolution dynamics can go fast or slow, and in good or bad directions.

The Santa Fe researchers explain how agent interactions can produce nonlinearities of avalanche proportions every now and then. But they do not often explain what activates the agents in ways that are useful for those of us studying firms. In Bak's (1996) sandpiles, for example, a falling grain of sand can be the 'lever' that sets off the movement of a few grains of sand or a large avalanche, but taken for granted in his analysis is gravity – the energy gradient that causes the sand to fall in the first place. We now turn to the physicists' exogenous (adaptive) tension theories to explain how agents become activated. If the levers that instigate coevolution are seen as sparks, adaptive tension can be seen as the cloud of gas waiting to explode into a nonlinearity event. Both are required!

Adaptive tension dynamics How can CEOs improve distributed seeing connectionist networks in their firms? How can they steer them toward more fruitful directions? Complexity theory points the way. It emphasizes critical values in adaptive tension and consequent phase transitions. By emphasizing one adaptive tension over others, CEOs can steer distributed seeing in one direction or another. Cramer (1993) identifies three levels of complexity – defined in Box 1.3 – depending on how much information is necessary to explain the complexity: Newtonian complexity, emergent complexity, and stochastic complexity. Complexity science (Nicolis and Prigogine, 1989) shows that the separation of the region of emergent complexity from the other kinds is a function of the ambient energy impinging on a system of agents. The region of emergent complexity is the 'melting zone' (Kauffman, 1993) between the first critical value, Rc1 (the 'edge of order'), and the second critical value, Rc2 (the so-called 'edge of chaos').

The boundaries of emergent complexity are defined by 'critical values', R_c (Cramer, 1993). Nicolis and Prigogine (1989) describe the function of R_c in natural science. Nothing is so basic to their definition of complexity science as the Bénard cell – two plates with fluid in between (Bénard, 1901) – equivalent to high heat at the bottom of a teapot and less heat at the top. An energy (heat) differential between the plates – defined here as 'adaptive tension', T (*T*emperature or *T*ension) – creates a molecular motion of some velocity, R, as hotter molecules move toward the colder plate. The energy differential in the Bénard cell

BOX 1.3 DEFINITIONS OF KINDS OF COMPLEXITY BY CRAMER (1993)*

Below the first critical value 'Newtonian complexity' exists where the amount of information necessary to describe the system is less complex than the system itself. Thus a rule, such as $F = ma = md^2s/dt^2$ is much simpler in information terms than trying to describe the myriad states, velocities, and acceleration rates pursuant to understanding the force of a falling object. 'Systems exhibiting subcritical [Newtonian] complexity are strictly deterministic and allow for exact prediction' (1993, p. 213). They are also 'reversible' (allowing retrodiction as well as prediction thus making the 'arrow of time' irrelevant (Eddington, 1930; Prigogine, 1997).

Above the second critical value is 'chaotic complexity'. Cramer lumps both chaotic and stochastic systems into this category, although deterministic chaos is recognized as fundamentally different from stochastic complexity (Morrison, 1991; Gell-Mann, 1994) since the former is 'simple rule' driven, and stochastic systems are random, though varying in their stochasticity. For random complexity, description of a system is as complex as the system itself – the minimum number of information bits necessary to describe the states is equal to the complexity of the system. Probabilistic distributions in stochastically complex systems allow some algorithmic compressibility. Thus, three kinds of stochastic complexity are recognized: *purely random*, *probabilistic*, and *deterministic chaos*. For this chapter I narrow the label to deterministic chaos, at the risk of oversimplification.

In between Cramer puts 'emergent complexity'. The defining aspect of this category is the possibility of emergent simple deterministic structures fitting Newtonian complexity criteria, even though the underlying phenomena remain in the stochastically complex category. It is here that natural forces ease the investigator's problem by offering intervening objects as 'simplicity targets' the behavior of which lends itself to simple rule explanation. Cramer (1993, pp. 215–17) has a long table categorizing all kinds of phenomena according to his scheme.

Note: * For mnemonic purposes we use 'Newtonian' instead of Cramer's 'subcritical', 'stochastic' instead of 'fundamental', and 'emergent' instead of 'critical' complexity.

parallels that between the hot surface of the earth and the cold upper atmosphere – hotter air molecules move upward and if they move fast enough, create storm cells. Complexity science cannot be understood without appreciating the role that T plays in defining the region of complexity between the 'edge of order' and the 'edge of chaos'. If T increases beyond R_{c2}, the agent-system jumps into the region of chaotic complexity. The system may even oscillate between the order and chaos basins of attraction – a chaotic state indeed! Definitions of attractors are given in Box 1.4. Thus, for molecular agents:

BOX 1.4 DEFINITIONS OF ATTRACTORS BY GLEICK (1987)

'Point attractors' act as equilibrium points. A system, even though oscillating or perturbed, eventually returns to repetitious behavior centered around the point attractor – traditional control style management decision structures may act in this manner (appearing as Newtonian complexity).

'Periodic attractors' or 'limit cycles' (pendulum behavior) foster oscillation predictably from one extreme to another – recurrent shifts in the centralization and decentralization of decision making, or functional specialization versus cross-functional integration fit here (also appearing as Newtonian complexity).

If adaptive tension is raised beyond some critical value, systems may be subject to 'strange attractors' in that, if plotted, they show never intersecting, stable, low-dimensional, nonperiodic spirals and loops, that are not attracted by some central equilibrium point, but nevertheless appear constrained not to breach the confines of what might appear as an imaginary bottle. If they intersected, the system would be in equilibrium (Gleick, 1987, p. 140) following a point attractor. The attractor is 'strange' because it 'looks' as though the system is oscillating around a central equilibrium point, but it isn't. Instead, as an energy importing and dissipating structure, it is responding with unpredictable self-organized structure to tensions created by imposed external conditions, such as tension between different heat gradients in the atmosphere caught between a hot surface of the earth and a cold upper atmosphere, or constraints in a fluid flow at the junction of two pipes, or tension created by newly created dissipative structures, such as eddies in a turbulent fluid flow in a canyon below a waterfall, or 'MBA terrorist' structural changes imposed in an attempt to turn around an acquired firm.

As a metaphor, think of a point attractor as a rabbit on an elastic tether – the rabbit moves in all directions but as it tires it is pulled toward the middle by the elastic tether where it lies down to rest. Think of a strange attractor as a rabbit in a pen with a fox on the outside – the rabbit keeps running to the side of the pen opposite from the moving fox but as it tires it comes to rest in the middle of the pen. The rabbit ends up in the 'middle' in either case. With the tether the cause is the *pull* of the elastic. In the pen the cause is *repulsion* from the fox unsystematically attacking from all sides.

- Below R_{c1} – the *edge of order* – agents show minimal response in reducing T – molecules vibrate in place but 'conduct' energy by colliding with each other.
- Above R_{c1} – the *edge of order* – agents show collective action toward reducing T. Gas molecules start bulk currents of 'convection' movement, as the molecules actually circle around from hot to cold and back to hotter plate, or generate strong bulk currents of air flowing up and down from earth's surface to upper atmosphere – the air turbulence and storm cells that create rough airplane rides.

- Above R_{c2} – the *edge of chaos* – the molecular movements become chaotic. For example, if T between hot lower air and cold upper air increases further, perhaps by the conflation of warm moist air from the south and cold air from the north, say over Kansas, R_{c2}, may be exceeded. At this point the storm cell may oscillate between two basins of attraction, order and chaos, that is, tornadic and nontornadic behavior.

Translating to firms, suppose a large firm acquires another firm needing a turnaround. Suppose T stays below R_{c1}; existing management stays in place and little change is imposed by the acquiring firm. There is little reason for people in the acquired firm to create new structures. Instead, there might be only 'conduction' type changes in the sense that new turnaround ideas percolate slowly from one person to another person adjacent in a network. If T goes above R_{c2}, complexity theory predicts chaos. Suppose that the acquiring firm changes several of the acquired firm's top managers and sends in 'MBA terrorists' to change the management systems 'overnight' – new budgeting and information systems; new personnel procedures, promotion approaches, and benefits packages; new production and marketing systems. And suppose that the acquired firm's culture and day-to-day interaction patterns are changed as well. In this circumstance, two basins of attraction could emerge: one centered around the comfortable pre-acquisition ways of doing business and resistance to change, and the other defined around demands of the MBA terrorists. The activities of the system could oscillate chaotically between these two basins.

Between R_{c1} and R_{c2} lies the organizational equivalent of Cramer's emergent complexity or Kauffman's melting zone. Here, network structures emerge to solve T problems. Using the storm cell metaphor, in this region the 'heat conduction' of interpersonal dynamics between sporadically communicating individuals is insufficient to reduce the observed T. To pick up the adaptive pace, the equivalent of organizational storm cells consisting of 'bulk' adaptive work-flows starts. Formal or informal structures emerge, such as new network formations, informal or formal group activities, departments, entrepreneurial ventures, and so on. Although the *T*s in organization science are unlikely to have the precise values they appear to have in some natural sciences (Johnson and Burton, 1994), a probability distribution of such values will exist for individual firms and each of their subunits. Although precise values of T for firms do not exist, we do know about symptoms indicating whether a firm is below R_{c1}, in between, or above R_{c2} (Brown and Eisenhardt, 1998; McKelvey, 2008).

Steps toward better-distributed seeing via emergent complexity[5]

Adaptive tension For distributed intelligence and seeing to be improved, CEOs need to ensure that the corporate brain is exposed to the full range of 'Ts' 'out there' – that surround the agents – that might energize emergent order. At GE, Jack Welch used 'Be #1 or 2 in your industry' – a very clear motivational valance. Respond to the T or your division 'will be fixed, sold, or closed' (Tichy and Sherman, 1994, p. 108; paraphrased). Thus, Ts are the root motivation causing agents to self-organize.

While agents in a teapot face just one T (heat), the adaptive tension confronting the many agents within a firm – as receivers – could appear as countless *T*s. In addition, there are many *T*s reflecting forces and constraints in the environment, not to mention

*T*s created by numerous agents within competing firms – from the CEO down to the people in engineering, production, marketing, sales, and so on. An agent network could emerge virtually anywhere in a firm around an initiative to produce a better part, product, marketing approach, new strategy, a cost reduction, and so forth. Consequently, there is danger in a priori trying to focus certain kinds of *T*s toward specific kinds of agents. This might preclude the emergence of the most effective new networks. But there is an equal danger in trying to flood every agent with every kind of *T*. It is also clear that 'selecting' the nature of the incoming *T*s based on preconceived CEO-level notions, as Roger Smith did at GM for a decade (Hunt and Ropo, 1998), puts blinders on the corporate brain. Toyota is well known for its system of increasing the awareness of workers about how well their designs and products compete against the competition – a small set of narrowly defined *T*s. Welch accomplished the same objective by defining *T*s very broadly as, 'Be #1 or 2 in your industry!'. This is a perfect example of using a simple piece of information to focus attention on a particular aspect of the competitive environment – everything is boiled down to one *T* that *drives* the lower-level systems without the command-and-control structure *defining* them. Strong corporate leadership is shown without setting up a suppressive command-and-control structure or otherwise inhibiting emergent distributed intelligence. Hamel and Prahalad's 'strategic intent' (1989) fits this perspective as well and their concept of 'stretch' equates to Welch's 'Be # 1 . . . '.

Critical values Assuming that agents are confronted by the appropriate Ts, managing the critical values aspect of adaptive tension requires three basic activities: (i) checking whether behavioral symptoms of Ts impinging on one or more agents are below, between, or above Rc; (ii) altering motivational valances to move the T levels into the region between Rc1 and Rc2; and (iii) widening the distance between Rc1 and Rc2.

As noted above, critical values are not precisely determined in firms – as they are in natural science. Nor does current research indicate what levels of *T*s are below, between, or above the critical values. For now we have to rely on behavioral symptoms for evidence about *T* effects. Brown and Eisenhardt (B/E) (1998) identify some symptoms. For example, as indications that *T* is *below* R_{c1}, B/E point to overbearing structure, fiefdoms, little novelty, and reactive strategizing. For evidence that *T* is *above* R_{c2}, B/E point to random communication, overcoordination, politics, modular structures disconnected, and sporadic intense experimentation too narrowly focused.

There are also direct symptoms of emergence. In general, *T* between R_{c1} and R_{c2} produces emergent dissipative structures, which then start reducing *T*, at which point they dissipate. For example:

1. Emergent social networks such as dyadic or triadic communication channels, informal or formal teams, groups, or other network configurations.
2. More effective networks within or across groups, more structural equivalence, better proportions of strong and weak ties, increased numbers of structural holes (Burt, 1992), more networks emerging between hostile groups – marketing with engineering, or with production, with suppliers, with customers, and so forth.
3. Emergent networks of any kind, networks that produce novel outcomes, new strategies, new product ideas, new directions of knowledge accumulation.
4. Networks that speed up rates of adaptive-event occurrence.

Widening the region of emergence requires operating on the definition of the critical values themselves – lowering R_{c1}, raising R_{c2} – rather than only trying to adjust the Ts to fall in between. Anything that gets networks to form more easily, or sooner, is essentially lowering R_{c1}. Raising R_{c2} requires training agents to develop (i) more effective emergent structures – so tension stops rising and starts dissipating; and (ii) higher 'tension tolerance' to handle higher tension levels before 'going chaotic'. For example, employees in high-velocity firms in Silicon Valley work routinely in an atmosphere of adaptive tension far higher than might ever appear in large dinosauric utility firms or government agencies.

Attractors The previous two subsections work on the 'fostering-and-speeding-up-emergence' part. Now we turn to the problem of 'steering' without inadvertently fostering the emergence of a suppressive command-and-control bureaucracy. Recall the definitions of 'point' and 'strange attractors' in Box 1.4.

Bureaucratic negative feedback systems center around point attractors. A visionary CEO operates as one – his/her vision is the goal, which becomes the equilibrium point toward which negative feedback-driven managerial control processes define the system. Since firms do need strong leaders, and since some people like being strong leaders and behave like strong leaders, it is pointless to think of avoiding point attractors. The trick is to aim these 'strong leader types' toward using point attractors that 'drive' the system toward reducing the Ts but do not 'define' them in the command-and-control ways that inhibit emergence. Ts *are* point attractors. Activities that serve to reduce Ts, thus, are point attractors. Hamel and Prahalad's 'strategic intent' could inadvertently become a point attractor rather than acting more like Welch's content-*less* tension directive – 'Be #1 or 2 or else . . . '. Mackey et al. (2006) detail how Welch did this, using quotes from Slater (2001) as evidence.

Remaining strong leader activities are best redefined to be strange attractors. This is probably the best way in which to view Bennis's (1996) 'herding cats' metaphor – the 'cage' effect of the rabbit and fox metaphor in Box 1.4. We may use what Morgan (1997, p. 98) refers to as 'cybernetic reference points' and 'avoidance of noxiants' to define the reflective cage of a strange attractor without defining goals that act as point attractors. Strange attractor 'definitions of the cage' must be created without determining specific or repeating paths – characteristics of point attractors and opposite the definition of novelty. Welch did this quite well (Mackey et al., 2006).

Incentives should encourage the proper delineation, separation, and development of point and strange attractors. It is easy to define point attractor incentives – 'Here is the goal and we will pay more if you achieve it'. Saying 'No' is all too easy in firms and seldom needs to be encouraged. Setting up 'inexpensive experiment' strange attractor systems seems more risky. Learning when to discontinue an experimental product development activity is problematic (Royer, 2003). Strange attractors also need to be made attractive for agents 'inside the cage'.

To accomplish this, good strategy depends on having effective strategy production processes inside organizations. We have defined a social information processing model that is a bottom-up and social network-oriented *community* process emphasizing distributed intelligence and social capital. This is very different from the purely *hierarchical organizational* one presented by Galbraith (1973) and Galbraith et al. (1993), which, though decentralized, is still very much a top-down creation.

A good strategy-finding process, then, depends on a CEO's ability to unleash the kinds of forces that produce the right kind of organizational climate – one that allows connectionist social networks to form. Needless to say, the fast- and farsight processes we discuss do not happen in just any old firm. *The Economist* (2001) gives an analysis showing that the CEO firing rate has dramatically increased in recent years – even before the dotcom bust. Bennis and O'Toole (2000) say it is due to the fact that boards cannot find CEOs with the right vision. We think leadership theory is at fault (Marion and Uhl-Bien, 2001; Mackey et al., 2006; Uhl-Bien et al., 2007). If CEOs are listening to leadership theorists such as Bennis (1996), they are applying archaic thinking to 21st-century knowledge economy problems.

Summary

In this subsection we drew from Prigogine, Haken, and Mainzer to explain how energy and/or tension levels exceeding the first critical value, R_{c1}, create dramatic instigations toward change in physical, biological, and organizational situations. We also drew on Holland, Kauffman, and others connected with the Santa Fe Institute to explain how new order emerges in complex adaptive systems composed of heterogeneous agents. We then showed how managers can use adaptive tension to activate the agents so as to create more active or vibrant complex adaptive systems, thereby increasing the possibility that coevolutionary dynamics toward new structure and processes are set in motion. The critical idea is for managers to create melting zones in their firms, that are in between the *edge of order*, R_{c1}, and the *edge of chaos*, R_{c2}. These adaptive systems, then, are more capable of the *fast*sight dynamics needed for a firm to meet the requisite complexity standards we set forth in the *far*sight section. We see Jack Welch as having done this better than most other CEOs.

Charismatic vision versus distributed seeing

> Charisma is narcissism looking for an echo. (Max Boisot, Sitges, Spain, 2003)

Could it be that leadership theory is antithetical to CEOs trying to create distributed seeing? Dansereau and Yammarino's (DY) (1998a,b) summary table (1998a, p. xxxix) shows leadership theory to be focused on attributes of leaders and their effects on groups of followers and on individual followers in dyads – corroborated by Klein and House (1998, p. 9). To use Dubin's (1979) phrases, this is mostly 'leadership in organizations' rather than 'leadership of organizations'. In the DY books, only Hunt and Ropo (1998) concentrate on leadership *of* organizations via their case analysis of Roger Smith's years as CEO of General Motors. The Klein and House (1998) chapter on charismatic leadership focuses on leadership of subordinates at different levels *in* firms – leader–subordinate dyads at different levels – rather than leadership *down through* a firm's several levels.

Leadership in the DY books is multilevel. Visionary leadership cascades down one level at a time. Bennis and his colleagues (Bennis and Nanus, 1985; Bennis and Biederman, 1996) zero in on leaders who successfully reorient multilevel sets of followers in organizations. They abandon trait and situational theories for a skill-based theory built around leaders able to get subordinates to follow their vision. Bennis (1996, p. 156) says:

> Leading means doing the right things . . . creating a compelling, overarching vision. . . . It's about *living* [original italics] the vision, day in day out – embodying it – and empowering every other person . . . to implement and execute that vision. . . . The vision has to be shared. And the only way that it can be shared is for it to have meaning for the people who are involved in it. *Leaders have to specify the steps that behaviorally fit into that vision, and then reward people for following those steps* [added italics].

But he also says the opposite: 'The problem facing almost all leaders in the future will be how to develop their organization's social architecture so that it actually generates intellectual capital' (p. 149).

Bennis follows the charismatic leadership theory of House (1977) and Nanus (1992). Klein and House (1998, p. 3) say 'charisma is a fire that ignites followers' energy, commitment, and performance'. In dwelling primarily on the 'mythic', 'heroic', 'visionary', upper echelon leaders, Bennis works at cross-purposes with distributed sensemaking and speeding up the rate of distributed seeing.[6] In the last quote above it is the brain of the leader that creates the vision and followers are rewarded (in the context of command-and-control structure) for carrying it out. And yet, as Bennis himself says, 'people at the periphery of organizations are usually the most creative and often the least consulted' (1996, p. 152). Bennis does not answer the question: 'How to lead the corporate brain without damaging its distributed intelligence or seeing ability?'.

How does the visionary CEO suppress emergent distributed intelligence? First, heroic visionary leaders tend to create 'strong cultures' (Peters and Waterman, 1982; Schein, 1990). The role of entrepreneurs as visionary creators of organizational culture has been noted (Siehl, 1985). Kotter and Heskett (1992) observe that organizational performance is connected to adaptive cultures and that leaders play a key role in culture change. Sorensen (2002) shows that strong cultures are assets in stable environments but liabilities in changing times. Leaders are seen as molding employees' views about a firm and defining their roles within it (Bryman, 1996). Willmott (1993) claims that culture management is simply a new form of managerial control. Bryman (1996, p. 285) notes that Martin's (1992) 'integration perspective' points to leaders who go about 'creating, maintaining or changing cultures' in the normative manner outlined by the foregoing authors.

Second, consider a recent discussion of CEO-level charismatic leadership by Waldman and Yammarino (1999). They focus on strategy formulation by upper echelon managers, that is, leadership *across several levels*. Three propositions are:

- 'Charismatic attributions toward the CEO at lower echelons will result in heightened organizational member effort and intergroup cohesion, especially under conditions of perceived environmental volatility' (p. 276).
- 'Intergroup cohesion will result in linkages regarding the performance objectives of units within an organization so that the subsequent performance of units will be co-coordinated toward higher-level organizational performance' (p. 277).
- 'Coordinated operational performance of subunits will lead to higher organizational performance, especially when units are interdependent' (p. 278).

These propositions are telling because they: (i) focus on leadership across several intervening levels of organization, thus fitting our focus on CEOs leading the entire firm; and

(ii) relate charismatic leadership to group cohesion and coordination which, then, leads to better achievement of 'objectives' – that is, point attractors.

Some leaders may have visions that are correct, innovative, and up to date in high-velocity environments. But what if the heroic leader's one brain is not up to the job? How to get the corporate brain to come to the rescue? Left unsaid, but nevertheless supported by the Waldman/Yammarino propositions, is the idea we wish to stress: upper echelon charismatic leadership produces cohesion and leader-defined 'groupthink' (Janis, 1972) across intervening levels where one would instead want to see emergent distributed seeing ability. Charismatic leadership, thus, produces a corporate brain mirroring the CEO's, and once it is made pervasive via incentive systems, it emerges as a pervasive, rigidifying corporate culture preserving the status quo groupthink.

We note parenthetically that CEOs, in effect, can shape their firm's internal selection environment. A good leader establishes mechanisms for generating variety and mechanisms for selecting from such variety once generated. Given Salthe's (1985) triadic structure, for example, the production of blind variations and selection (Campbell, 1965) occurs at all three levels. The promulgation of a severe selection environment, however, takes on the characteristics of a strong point attractor. If selection is too strong, diversity is driven out at lower levels. Thus, in organisms, a mutation rate remains, which keeps diversity going. If too strong a selection process were to reduce the error rate, species could lose adaptive capability. Argyris (1957) referred to this as 'passive dependence' among lower-level organizational employees (agents). Given Bhaskar's three planes of transcendental realism, too severe a CEO selection process drives causality on the lower planes underground, as it were, bringing to life rebellious informal organizations or, given our perspective, denies the firm the advantages of distributed seeing and intelligence.

Summary

In this section we reviewed basic arguments why current leadership theory works to shut down rather than enable distributed intelligence and fastsight. While it can produce strong followership, control-oriented visionary charismatic leadership can easily produce groupthink. The only way around this is for leaders to enable distributed intelligence by setting the fastsight dynamics in motion, as we discuss in the fastsight section.

Conclusion

We translate strategic foresight into *far*sight and *fast*sight. The former focuses on *supra-forces* operating above the plane of industry competition, which is the plane of Porter's (1980) five forces. The latter focuses on the *sub-forces* operating below the plane, that is, within a firm. Drawing on complexity science, we then pursue a CEO-oriented discussion about how to foster both far- and fastseeing. We first concentrate on farsight, which is a means of helping firms look past emergent discontinuities, see them further down the road, or catch them in the emergent stage. After developing a theory of pattern formation rooted in complexity science, we use the same principle to outline a pattern-search process based on understanding when adaptive tensions become order parameters. This becomes the pattern-finding task facing the emergent connectionist networks. This consists of an $\boldsymbol{i}^2$ by $\boldsymbol{k}$, $\boldsymbol{v}$, $\boldsymbol{t}$ search space. The complexity dynamics leading to efficacious fast- and farsight are recursive. Then we use complexity theory to discuss how energy differentials or adaptive tensions rising above the first critical value, R_{c1}, set off phase transitions that initiate self-organization among agents comprising social networks in firms. This 'technology' develops connectionist, cellular networks (Miles et al., 1999) of human agents with distributed seeing capabilities. This leads to a firm's fastsight capability. We conclude by briefly mentioning ways in which control-oriented visionary CEOs can inadvertently shut down rather than enable efficacious, emergent, connectionist networks in their firms.

Bennis and O'Toole (2000) argue that lack of vision is what has led to the increased CEO firing rate that they observe. *The Economist* (2001) corroborates that the CEO firing rate has, indeed, gone up – they show that almost 1,600 CEOs had been fired in the 19 months before they published their story. It is obviously tempting for boards to try to hire CEOs who 'appear' to be visionary leaders, and who 'apparently' can see into the future. But, the idea that boards can actually tell who has vision and who has not seems ludicrous. The idea that leadership theorists think that boards can do this seems equally ludicrous.

We take a more scientific approach, arguing that 'foresight' is better translated into fastsight and farsight. This idea builds on Bhaskar's (1975) 'transcendental realism'. It also builds on Salthe's notion of 'triadic structure' as the basic analytical 'unit' in all of science – to wit, that all analysis of any *system* must take into account actions of its *components* (agents) and its *environment*. For us, fastsight is a function of a firm's distributed intelligence from networked employees holding heterogeneous human capital and farsight is a function of using fastsight and adaptive tension to accomplish expedited pattern processing of its exogenous environmental complexity. In this way we use elements of basic philosophy and basic science to decompose the wizard-like concept, foresight, into two component elements, fast- and farsight. Our analysis shows that there is nothing divinely omniscient about either fast- or farsight.

Creating the needed cellular networks (Miles et al., 1999) in firms to pursue the fastsight path is not easy. McKelvey (2004a) and Mackey et al. (2006) present complexity-based 'simple rules' essential to enabling emergent social networks. Boisot (1998) discusses essential organizational conditions for knowledge development. We also present the so-called '$\boldsymbol{i}^2$ by $\boldsymbol{k}$, $\boldsymbol{v}$, $\boldsymbol{t}$ array' here, which offers a plan for pattern processing under conditions where one can expect vast numbers of possible patterns. We also develop our pattern-processing approach in more depth elsewhere (Boisot and McKelvey, 2006a,b), focusing more on the speed problem.

We conclude by stressing the recursive nature of developing far- and fastsight. Improving the one improves the other. Our use of complexity science shows that CEOs need to focus on environmentally imposed adaptive tensions that, then, may be used to initiate, motivate, and maintain their cellular networks in the fastsight mode. The presence of well-working cellular networks leads to faster pattern processing, which leads to efficacious farsight. Neither can work without the other. The bottom line is that complexity science offers a strategy-finding process *away* from foresight, vision, and witch doctoring or, put more bluntly, the hope of finding modern versions of the Oracle at Delphi. It takes internal complexity to develop strategies suitable for strategic success in a complex external environment.

Notes

1. 'Agent' is a generalized term used in agent-based computational modeling that can refer to atoms, molecules, biomolecules, cells, organisms, species, people, cognitive elements, groups, organizations, societies, and so on.

2. Quoted in Hamel (2000, p. 102).
3. As we detail early in the fastsight section, the region of emergent order (emergent complexity) exists between R_{c1} and R_{c2} (Cramer, 1993; McKelvey, 2004b), but for our purposes here only R_{c1} is important. Tension above this critical value is what activates agents – that is, the tension rate is above the threshold gate value for a sufficient number of agents that the coevolution process begins.
4. Note, however, that adaptability is most likely to occur with 'moderate' diversity (Kauffman, 1993), such as is found on a Galapagos island. Adaptation speeds up if the population's gene pool is attenuated as occurs on each of the Galapagos islands, but virtually stops if the gene pool is grossly attenuated.
5. A more detailed outline – in the form of 'simple rules' – of what CEOs can do to enable emergent, efficacious, connectionist networks in their firms appears in McKelvey (2004a) and Mackey et al. (2006).
6. As noted earlier, Jack Welch got around this problem by promulgating a 'process' vision that was actually based on the 'adaptive tension' we discussed earlier. The trouble emerges when the top-level visionary insists upon specific 'content agendas' that subordinates are incentivized to carry out.

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