Complexity, Decision-making and Requisite Variety

Abstract:

Ockham's famous razor, *lex parsimoniae,* is a principle that is reflected in many spheres of enterprise .The extraordinary number of commercial websites offering simple solutions to complex business problems suggests that the market for the 'silver bullet' solution to complexity remains strong. Implicit in many popular management methodologies is the supposition that with accurate data, simple, stepwise solutions are appropriate for complex situations, as they are for simple ones. Particularly in large, multi-owner, multi-national, multi-team enterprises, reality does not support this assumption. Change is frequent, rapid and often unexpected. It is well known that data gathering under turbulent conditions is unreliable. Nevertheless, organisations continue to favour simple management methodologies based on a non-complex world view, in which cause and effect are treated as if they are related linearly. Recent research also suggests that under turbulent conditions line and project managers are not using the simple methodologies that organisations have introduced. Following from Ashby and others, this paper explores arguments for approaches that provide the "requisite variety" needed to address complexity in turbulent environments.

Complexity, Decision-making and Requisite Variety

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It is vain to do with more what can be done with less.
Entities must not be multiplied beyond necessity!
--William of Occam (*c*. 1285–1349)

"... *the methodological tool that is needed in not a razor but a prism resolving conceptual medleys into the spectra of their meanings*..."
(Karl Menger, 1961: 332).

Introduction

Executive and project leaders are responsible for making decisions in contexts where at least some parameters are unknown and, even unknowable. Decisions from which critical actions ensue are made under extreme pressure of time and often without access to sufficient or relevant information. Debates promulgating the virtues of simplicity over complexity, and vice versa, have in one form or another been running for thousands of years. The current resurgence of interest in complexity, particularly in the light of recent world events that can only be explained by non-linearity and emergence, provides renewed emphasis for a discussion about how we tackle difficult issues under conditions characterised by non-linearity and emergence, so-called complex contexts.

This chapter begins by tracing in summary ideas of simplicity and variety, as dominant and persistent themes in the philosophy of science. The discussion continues to explore how these ideas are expressed in decision-making practice when leaders address unstructured problems

in complex contexts. It then discusses the conditions needed for robust decision-making when problems are complex.

The quest for simplicity

There is a strong philosophical tradition underpinning a quest for simple answers to universal questions. William of Occam (*c*. 1285–1349) is popularly quoted as having said: "Entities should not be multiplied unnecessarily." In its many derivative forms, this proposition eventually became known, in the 19th century, as Occam's Razor, *lex parsimoniae,* or the Law of Parsimony. However it is often inaccurately summarised as "...the simplest explanation is most likely the correct one..." (Ariew, 1976). The misinterpretation might reflect a frequently recurring theme in science - a quest for solutions whose elegance rests in their simplicity. Bertrand Russell offers the same idea in another form: "Whenever possible, substitute constructions out of known entities for inferences to unknown entities" (Epstein, 1984;119), echoing Newton's *hypothesis non fingo* (rule 1 in Book III of the Principia): "We are to admit no more causes of natural things than such are both true and sufficient to explain their appearances". Therefore, to the same natural effects we must, so far as possible, assign the same causes..." (cited in Hawking, 2003: 731). However the aim behind appeals to simplicity in such contexts is more about shifting the burden of proof, and less about refuting the less simple theory outright (Baker, 2004). As Bertrand Russell wrote in 1924:

> *One very important heuristic maxim which Dr. Whitehead and I found, by experience, to be applicable in mathematical logic, and have since applied to other fields, is a form of Occam's Razor. When some set of supposed entities has neat logical properties, it turns out, in a great many instances, that the supposed entities can be replaced by purely logical structures composed of entities which have not such neat properties. In that case, in interpreting a body of propositions hitherto believed to be about the supposed entities, we can substitute the logical structures without altering any of the detail of the body of propositions in question. This is an economy, because entities with neat logical properties are always inferred, and if the propositions in which they occur can be interpreted without making this inference, the ground for the inference fails, and our body of propositions is secured against the need of a doubtful step. The principle may be stated in the form: "Whenever possible, substitute constructions out of known entities for inferences to unknown entities."* (Russell, 1924: 160, cited in Linksy, 1999:132)

Russell's intention was to show that mathematics did not rely on intuition in Kant's sense, because mathematical truths could be reduced to logical truths via a series of definitions. "On this account, then, a construction is simply a definition, with certain goals; namely the reconstruction of certain 'neat' features of some purported entity as derivable from a theory of some other sort of entity in a prior theory of those entities." (Linsky, 1999:133). Linsky argues that this is not a nominalist reduction, the ontological commitments of arithmetic remain after reduction. Russell's aim was to derive logical or 'neat' properties from logical principles rather than having to assert them by postulate (Linsky, 1999).

A similar sentiment also appears in the writings of Albert Einstein. "The supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience" (Einstein, 1934:164).

In other words it is better to have a simple theory if it explains all of the evidence. Gell-Mann (2007) in his lecture on beauty and truth in physics, references both Newton and Einstein. He revisits the link between simplicity and elegance, even equating simplicity with beauty. "When the mathematics is very simple ... that is essentially what we mean by beauty or elegance." (2007; accessed 20-9-11).

An apparent counterpoint - variety

In the history of philosophy of science there is another tradition which contests the idea that the construction of the universe is underpinned by simple fundamentals. Occam's Razor as a principle can be used to eliminate unnecessary irrelevances, but some also argue that it can constrain the development of imaginative theories (Menger, 1961; Miller, 1990). For William of Occam, the immediate knowledge of a singular object was concrete and an excess of generalisation was synonymous with confusion (Pecker, 2004). Walter of Chatton (1290–1343), a contemporary of William of Ockham, was one of the most energetic and gifted critics of Occam's influential brand of nominalism. He stated his position as*:* "If three things are not enough to verify an affirmative proposition about things, a fourth must be added, and so on..." (cited in Fitzpatrick, 1971:91). Positions apposite to the virtue of simplicity also appear in the writings of Leibniz (1646-1716) and Kant (1724 –1804) in their search for the fundamental basis of physical existence. Leibniz argued at one point that that God created the most varied and populous of possible worlds and Kant eventually came to state that: "The variety of beings should not rashly be diminished." (Kant, Trans. Smith, 1950, cited in Churchland, 1984:133). As Watkins (2001:122) explains: Kant came to reject the idea of a simplicity of substance "... despite his attempts in the *Physical Monadology* to retain the simplicity of substance, in the *Metaphysical Foundations*, Kant argues that one cannot provide a coherent account of impenetrability in terms of simples. Thus he is ultimately forced to give up on simplicity, asserting instead in the infinite divisibility of matter."

Both Leibniz and Kant were exploring conjunctions between their understanding of the physical world and the realm of metaphysics. Rejecting the requirement of simplicity "...suggests that one can start with the physical world and then simply see what it requires, fulfilling these requirements by whatever metaphysical means one has at one's disposal." (Watkins, 2001:123). However some would argue that the consequences of focussing on simplicity as a dominant paradigm were significant. As Pecker (2004) explains, Newton's rule had the effect of refuting Descartes' vortices, as well as his theses about the propagation of influences and the non-existence of a vacuum which were later verified. Pecker also cites modern misuses of the Law of Parsimony in what he describes as "... the facile acceptance of the Big Bang in the 1950's, despite cogent criticism ... It was so simple to explain with one simple theory, three major phenomena that have been observed..." (2004:187).

An argument against simplicity, developed initially by William Ross Ashby, found a level of resonance in cybernetics and information science. Ashby demonstrated, by means of a lengthy mathematical proof, that if a system is to be stable the number of states of its control mechanism must be greater than or equal to the number of states in the system being controlled. Ashby states his law as "only variety can destroy variety" (Ashby, 1956, p. 207). Originally developed for application to the study of problems in biology Ashby proposed his "Law of Requisite Variety" in response to the Shannon Information Theory (1948) which deals with "incessant fluctuations" or noise in systems (Ashby, 1956, p. 108). In Information Theory,

the Requisite Variety condition can be seen as a simple statement of a necessary dynamic equilibrium condition. Otherwise stated, Ashby's law explains that "the variety within a system must be at least as great as the environmental variety against which it is attempting to regulate itself. Put more simply only variety can regulate variety" (Buckley, 1968: 495). Or, as Weick (1979: 189) elaborated: "If a simple process is applied to complicated data, then only a small portion of that data will be registered, attended to, and made unequivocal. Most of the input will remain untouchable and will remain a puzzle to people concerning what is up and why they are unable to manage it." In 1970, Conant who was working with Ashby, produced the Good Regulator Theorem (Conant, 1981) which states that to achieve stability or dynamic equilibrium, an autonomous system must acquire an internal model of its environment. Stafford Beer also came to define variety as "the total number of *possible* states of a system, or of an element of a system", and restates the Law of Requisite Variety as: "Variety absorbs variety" (Beer 1979: 276). Beer (1981) applied this to management problems, such as allocation of resources necessary to maintain process viability.

A mathematical argument in favour of variety was also developed by Karl Menger (1961: 331) who also argues that mathematicians are much too parsimonious with regard to variables. In response he formulated his Law Against Miserliness which has been stated as "Entities must not be reduced to the point of inadequacy..." As Menger, (1961: 332) explained: "What mathematics-scientific methodology needs is ... a censure of miserliness. It is vain to do with less what requires more...the methodological tool that is needed in not a razor but a prism resolving conceptual medleys into the spectra of their meanings, or if one wishes to remain in the tonsorial domain of the razor, a comb disentangling and straightening out the various threads of thought." In this statement of his 'law' Menger touches on a fundamental apparent point of difference between the two paradigms, that simplicity provides a single lens whereas variety allows multiple views of the system.

Where does the quest for simplicity come from?

Questions that keep recurring for the authors of this chapter are the following: Is this fascination with the idea of simplicity, in the form of universal laws, simple explanations for everything, the association of elegance and even beauty with simplicity, fundamentally a romantic expression of a need for order and control of a universe that is clearly beyond our control? That so many eminent thinkers have argued the cause of simplicity, equating it with elegance and even beauty, makes it hard to dismiss as an idea. Are these ideas transferrable? Can they be applied to the world of business or do they legitimately only remain in the realm of science and metaphysics? From Occam, to Newton, to Leibniz, to Kant, to Gell-Mann, the search is for understanding of the physical nature of the universe; ways of understanding the building blocks of our existence. Gell-Mann (2007) for example, does not deny complexity. However he emphasises that all complex systems are based on an arrangement of simple fundamental components. The underpinning idea here moves from simplicity to variety. Gell-Mann is a self-confessed theorist. Ashby, Conant and Beer, on the other hand were cyberneticists, practical scientists, investigating remedial interventions in complex systems that might be closer to the world of business. However we argue that it is not the divide between theory and practical application that distinguishes the two paradigms.

In spite of the complex reality of organisational existence there is also strong anecdotal evidence in support of a pervasive quest for simplicity in the practical world of business. The extraordinary number of commercial websites offering simple solutions to complex business problems suggests that the market for the 'silver bullet' solution remains vibrant and alluring. Also, implicit in many popular management methodologies is the supposition that, with accurate data and logical methods, simple, stepwise solutions are both possible and effective for

complex problems. This approach also resonates with a positivist world view, that understands the physical universe through decomposition. We argue that a focus on simplicity, by itself, is counter-productive in the practical world of business. It is vital the organisational and project leaders are able to make robust, defensible decisions under conditions characterised by non-linearity and emergence. Recent world economic crises suggest that decision-making in conditions of complexity can be far from effective. Surprisingly, one of the drivers for simplicity can be success. Miller (1990, 1993) argues that a drive towards simplicity can be a product of initial success. Success increases focus on those solutions that seem to be responsible for the success, encouraging convergence towards simple solutions, processes and methods. This approach ultimately leads to failure, the narrowed focus having the effect of obscuring other important information and paradigms. What Newton, Einstein and others achieved is both simple and elegant, but the pathway to simplicity was not. The pathway to simple elegance is via a deep understanding of complexity. The 'quick fix' or 'silver bullet' almost always takes us directly from simple to simple rather than from complex to simple. Without the integration of complex information to find simple elegance, the alternative can be from simple to even more simple.

Nevertheless simplicity is useful. Seeking variety without ever simplifying might be impractical. Simplicity is essential when communicating complexity to others. The organisational leadership research stresses that communicating with clarity and brevity is more important than direction, particularly if direction is unknown (Dewan & Myatt, 2008). There is a real danger in only looking for simplicity because we will often do the wrong thing. Motivated by various intentions, or just in response to information overload or stress, we might filter too early and therefore only allow ourselves access to a very small part of the information (Miller & Ross, 1975). Most people can deal with simplicity. That's why simplicity is popular. It is within reach. However, the simplicity to which most people have access, isn't the simplicity of the gifted. The Newtons and the Einsteins will aim for simplicity, but be willing and able to go through complexity to get to the apparently simple. Most of us will never able to grasp that level of the complexity.

It is also important to stress that simplicity and variety are fulfilling very different functions. The theoretical mathematicians and physicists looking for simplicity are seeking general theories. Theorists focussing on variety are usually looking for something situated in lived reality. Complexity only exists in lived reality; the reality that practitioners experience as they address messy and unstructured situations. Evidence from post-analysis of multi-national projects, usually collected for the purpose of litigation, illustrates the multiplicity of causal factors that contribute to emergent risk patterns in these complex endeavours (see Ackerman, Eden & Williams, 1997; Ackerman & Eden, 2001; Eden & Ackerman, 2004). Understanding variety is therefore useful. It is the key to working with complexity, but remaining with variety might mean that nothing gets done in a practical sense. To get to simple that is useful and still meaningful we need to structure ways to get to simple from complex, and preferably also use structures that allow us to move fluidly between the two perceptions. However, first we need to understand how we make decisions when working with complexity.

Working with complexity

How leaders make decisions under conditions of complexity

The psychological literature offers conflicting information about how leaders make decisions under conditions of complexity. Early theories propose that people habitually try to reduce uncertainty (Berger & Calabrese, 1975) particularly with respect to human interactions. More recent theories propose that people experience uncertainty variously, not simply as an

uncomfortable tension demanding reduction (Babrow & Stohl, 1996; Babrow, Kasch & Ford, 1998; Babrow, Hines & Kasch, 2000; Ford & Brashers, 2001). According to Nystrom and Starbuck (1984:55): "What people can see, predict, understand depends on their cognitive structures - by which we mean logically integrated and mutually reinforcing systems of beliefs and values. Cognitive structures manifest themselves in perpetual frameworks, expectations, world views, plans, goals ...myths, rituals, symbols ... and jargon." However there is also evidence that cognitive structures change over time (Suedfeld & Tetlock, 2001). They are not necessarily static and can be contextually dependent.

In complex situations, decision-makers are not presented with problems and alternative solutions. Decision-makers must search for problems, as well as solutions, and they must actively search for information, since information is not always readily available. Decision-making in complex environments requires what is generally referred to as *cognitive complexity* ability. *Cognitive complexity* describes how people differentiate among aspects of, or perspectives on, a particular problem (differentiation), and the degree to which people then relate those perspectives to each other within some coherent framework (integration). Differentiation is necessary but not sufficient. It is only part of the process. You can differentiate without integrating. However the reverse does not apply, you cannot integrate without having differentiated. Integration involves reconstructing differentiated information into a meaningful new whole (Walker & Watson, 1994). High cognitive complexity capability is most important in unstructured, or messy, decision situations (Schroder *et al.,*1967) of the kind that would occur in turbulent organisational environments. The essential step of integration is sometimes omitted, or only partially realised, particularly in models that stress decomposition, such as those that have dominated many aspects of management thinking, including project management.

Information searching

Fundamental to cognitive complexity capability is access to information. It would be reasonable to assume that robust decision-making in complex environments requires access to a rich variety of information. However studies of how managers choose information sources indicate that they rely on quite simple and crude heuristics (Aguilar, 1967; Mintzberg, 1973). Additionally, Cyert and March (1963) described the use of information in many organisations as simplistic. Information search is most often local and limited, with a tendency to rely on the most readily available, or familiar, source of information. There is also evidence that during perceived complexity the search for information narrows. In fact, an increase in perceived complexity acts as a significant disincentive to executives to continue scanning the environment (Boyd & Fulk, 1996).

This is a surprising result. Apart from the obvious need for information for sound decision-making, one might also expect that leaders would engage in wider and deeper search behaviour, just because additional information might lead to an increased sense of security. However Boyd and Fulk's (1996) results support earlier research findings; that comprehensive information search and decision-making is more likely to occur in stable environments, as opposed to unstable, environments. They also found that if an event is not considered to be sufficiently important to rate regular monitoring, even high levels of threat do not result in increased monitoring levels (Fredrickson, 1984; Fredrickson & Mitchell, 1984). Stabell (1978) also suggests that secondary decisions to filter information are frequently not conscious. Neither are they recognised as being unconscious processes. Information source selection is mainly performed as a judgment or classification rather than as a choice, in which alternatives are explicitly considered and objectives explicitly recognised. Unfortunately there is little evidence in the literature to suggest that these observations are not still relevant.

Cognitive complexity

Several studies link complexity of an individual's general conceptual understanding with the level of information processing in semi-structured and unstructured tasks (Harvey, Hunt, & Schroder, 1961; Schroder, Driver, & Streufert, 1967,1969; Schroder & Suedfeld, 1971). Cognitive complexity capability varies substantially with individuals and groups (Schroder, et al., 1967).The brain has been described as comprising interconnected neural nets with an enormous amount of redundancy in pathways. Of particular importance to complexity is the brain's ability to recognise patterns (Khalil & Clark, 1989; Churchland, 2002; Clark, 1997; Clark & Eliasmith, 2002). Enhanced ability to differentiate and to integrate complex information and to find meaningful patterns would appear to be vital for business and project leaders, particularly when the situation is complex.

For messy, or unstructured situations, the ability to integrate information is often seen as more important than the cognitive differentiation component of cognitive complexity (Stabell, 1978). Clift and Vandenbosch (1999) note that, for complex projects, project leaders must be able to coordinate disparate groups and use high levels of improvisation. They also must be able to integrate many types of information. Saarinen (1990) found that in instances where stakeholder assessments of project success were low, internal integration was also found to be low. Hauschildt et al. (2000), as part of a survey of 58 organisations, found that integrative thinking, which they defined as the ability to think analytically while bringing together many different ideas, was a key attribute of successful leaders. The most successful leaders, scored higher in integrative thinking than other, less successful leaders. Yiu and Saner (2000) also found that high levels of cognitively complex thinking was required in order for managers to be effective in global efforts. More recently, Green (2004) found that project leaders displaying higher levels of cognitive integration performed better in project definition tasks than those with lower cognitive integration scores.

Stress

More often than not, when a situation is complex, decision-making involves multiple parties and occurs under stress. R & D projects in the pharmaceutical industry are good examples of projects that are characterised by genuine complexity. Usually, decision-makers need to take account of many regulatory demands, financial concerns exist because clinical trials are costly and prone to failure, and they need to respond to organisational ambiguities, with more than one governing body within the organization, and there is severe schedule pressure, associated with time to market. It is important to recognise that emotion, rather than strict logic, informs many decisions under these circumstances. As Styhre et al. (2010) found when stakes are high people do not behave in a linear rational manner and standard processes and procedures are not adhered to. Decisions are made on the basis of emotion rather than evidence and previously careful decisions based on evidence are overturned in an apparently arbitrary manner. For example, high levels of anxiety due to diminishing returns on investment in R&D resulted in members of the project executive boards overturning earlier decisions.

Organisations operating in uncertain environments use fewer formal learning procedures than those in certain environments (Ellis & Shpielberg, 2003; Hovarth *et al*., 1981). This has important implications for the role of information in decision-making processes under stressful conditions. Information becomes meaningful as a consequence of how it is filtered, interpreted, shared and ultimately used (Heath, 1994). This is often referred to as the organisation's absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002). Without ways of absorbing the information, organisations and programmes or projects, which depend upon their sponsoring organisations for intelligence, may not be able to access the knowledge needed to make appropriate decisions.

Other effects of stress on information search and management have also been observed. Continuous information collecting can be symptomatic of decision paralysis. As Feldman and March (1981) note, a common organisational response is to keep on collecting information, resulting in users becoming overloaded and the quality of decisions and organisational knowledge becoming impaired, contributing to a further increase in perceptions of uncertainty. This can be a vicious cycle. When organisations lack the right mechanisms for information processing, information gathering alone is not sufficient for reducing uncertainty. Without appropriate processing mechanisms gathering more and more information, things might actually get worse (Ellis & Shpielberg, 2003).

Why focus on integrating variety

There are many reasons why simplistic approaches are less than satisfactory when dealing with messy, or unstructured situations. Miller (1993:117) argues that cognitive simplicity has shown to contribute to "...dominance of a single goal or subunit, information systems and routines that reflect a narrow range of skills and concerns, and a lion's share of resources going to one central tactic or activity…" but also to the "... narrowing, increasingly homogeneous managerial 'lenses' or world views that often underlie ..." simplicity. In addition, innovation is less likely to occur without integration and reconfiguration of available information (Miller, 1990). Simple approaches seek a quick narrowing of the search field to focus on a few options, in order to produce a quick, and ostensibly, efficient response. However, a simple solution that has local validity can also run the risk of being unable to address wider ramifications of the problem at hand. Or, due to effects of non-linearity and emergence, a simple, local response can have far reaching consequences, which are both unexpected and difficult to trace to their origins.

Cognitively complex thinking has been shown to be more effective in reducing conflict, in achieving robust, shared negotiated positions and even avoiding wars (Christie, Wagner & Winter, 2001). Walker and Watson (1994) studied the impact of crisis management strategies, stress, and groupthink conditions on the cognitive complexity (particularly their cognitive integration ability) of British decision-makers in 10 decision-making episodes during two Anglo-German crises in 1938 and 1939. Simulation studies reveal that those who are low in cognitive complexity ability are three times as likely to rely on competitive actions, than those who are high in cognitive complexity ability. In another study, players who were low in cognitive complexity ability were more likely to use violence when frustrated (Driver, 1965; Schroder, Driver & Streufert, 1967). Complex negotiations require parties to be able to assimilate and balance the many different complicated issues (Santmire *et al*., 1998). However, negotiated agreements, require acceptance by both sides (Allison & Williams, 2010) and cognitive complexity capability needs to be high on both sides, or at least matched (Pruitt, 1981; Pruitt & Lewis, 1975). Although this research suggests a direct causal relationship between cognitive complexity and negotiated outcomes, it cannot answer a critical question: in historical crises, what causes the changes in cognitive complexity in the first place? Stress is one possibility. Crises are stressful, and stress has predictable effects on cognitive integration ability. The *disruptive stress hypothesis* suggests that high levels of stress (such as during a crisis) can actually decrease cognitive complexity capability because stress depletes the cognitive resources necessary for complex thinking (Suedfeld & Rank, 1976; Suedfeld, Corteen, & McCormick, 1986; Wallace & Suedfeld, 1988). As cognitive complexity capability is variable, the ability to apply different levels of complexity to different situations may be more important for leaders (Suedfeld, 1992) together with increased consciousness of how stress affects cognitive complexity capacity.

Group dynamics almost certainly plays an important role in complex situations. The *groupthink* model suggests that during stressful times, such as crisis situations, psychological pressures can

lead group members to unequivocally accept the opinion of their leader, even if they actually disagree with it (Janis, 1982, 1989). Signs of groupthink include a reluctance to criticise other members' opinions, ignoring input from qualified persons outside the group, and failing to explore potential alternative options to the leader's viewpoint. Miller (1990) also cites groupthink as a contributing factor in creating organisational simplicity. Perhaps not surprisingly, there is evidence of a link between groupthink and cognitive integration. Tetlock (1979) found that decision-makers exhibiting groupthink demonstrated less cognitive complexity capacity than those not exhibiting groupthink. Bordin's (1998) study with military officers also found that those who were low in cognitive integration ability were more prone to the influences that lead to groupthink when responding to an imaginary crisis, such as a simulated terrorist attack.

Enhancing cognitive complexity capacity

Originally considered to be a relatively stable personality trait, cognitive complexity capacity has now been shown to be sensitive to environmental cues such as stress, value conflict, and accountability pressures (Suedfeld & Tetlock, 2001). Certain situations seem to enhance individuals and groups cognitive integrative capacity. Particularly helpful is exposure to different perspective frames, either through metaphorically 'stepping into another person's shoes' or through actual acculturation, where people are deeply exposed to other ways of thinking.

How problems are perceived, the evaluation of probabilities and outcomes can shift significantly when the same problem is framed in different ways (Tversky & Kahneman, 1981). In their Acculturation Complexity Model (ACM), Tadmor and Tetlock (2006) argue that individuals who cope with cultural conflict by internalising the values of other groups (such as becoming bicultural) will respond in reliably more complex ways than those who choose to adhere to the values of only one cultural group. They argue this is due to the greater dissonance biculturals experience during the acculturation process. Tadmor, Tetlock and Peng (2006) extend this model and suggest that biculturals' greater capability for complex responses will also generalise to other areas not directly related to the cultural domain. However they qualify this by suggesting that cognitive complexity capacity might also context specific. For example if it is acquired during a conflict situation it might not transfer to other contexts.

Another vital ingredient in leaders' capacity for integrative complexity is access to rich and relevant information. When organisations lack the right mechanisms for information processing, information gathering is likely to insufficient, or even counter-productive. Without appropriate processing mechanisms gathering more and more information, might actually make things worse (Ellis & Shpielberg, 2003). It is important that leaders ensure that information collection is comprehensive, can be utilised appropriately, and that information collecting is not continuing for its own sake.

Finally, raising leaders' awareness of the mechanisms governing information search and decision-making under conditions of complexity might go some distance to increasing consciousness of the decision process itself and the consequences of lack of attention. However organisations also need to structure ways of helping leaders to develop and maintain high levels of cognitive complexity, with a particular focus on cognitive integrative capacity. There is evidence that in times of stress, standard management procedures are not followed anyway (Styhre *et al*., 2010). Hence the usefulness of limited or simple paradigms during stressful, complex situations should be questioned. As others have argued, reducing and simplifying processes and procedures for the sake of efficiency, or limiting access to information, or restricting and controlling paradigms to a few dominant themes, forcing convergence to the

simple, might be creating recipes for failure in the long term (Miller, 1990, 1993). Therefore an emphasis on variety might, at the very least, include encouraging leaders to explore multiple paradigms, adopt multiple perspectives and promote the use of multiple methodologies to address the variety that characterizes complexity.

Conclusion

In concert with other important theorists, William Ross Ashby argued that system complexity can only be dealt with by variety. This argument is counter-balanced, in theoretical physics as well as the practical world of business, by an equally vigorous search for simplicity. It is easy to confuse the elegant simplicity of universal theories - general theories obtained through deep understanding of complex systems - with the countless 'silver bullet' solutions offered in the business literature. The latter may be simple solutions derived from simple analysis. Even though complex systems may be constructed from simple elements and relationships, the complexity that emerges from initial simplicity rarely responds to simple interventions. This is largely because simple interventions can only access very small parts of the information available in a complex system. Simple approaches may be appealing, particularly in times of stress. Under stress, managers and organisations tend towards a reduced capacity to gather appropriate information, an impoverished ability to integrate complex information and sometimes negative group dynamics effects. Where leaders are expected to solve multi-dimensional problems that are unstructured, or messy, high levels of cognitive complexity capacity is needed by decision-makers. Cognitive complexity capacity, particularly the ability to integrate complex information, may be enhanced through active search for multiple perspectives, adoption of multiple frames and approaches. An awareness of the many pitfalls that prevent access to appropriate information and that can interfere with decision-making should also be helpful. Simple approaches should to be treated with suspicion when the problem is complex. Understanding variety requires variety. For business leaders who are grappling with complex problems in practice, Occam's razor might be a very useful metaphor for communication. To achieve the requisite variety needed to respond effectively to complexity, one must evoke Karl Menger's revolving prism.

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