

Chapter 2 Complexity and Understanding

Me gusta la complejidad.

Juan José Falcón Sanabria, Spanish composer¹

La uniformidad limita, la variedad dilata; y tanto es más sublime, cuanto más nobles perfecciones multiplica.

Balthasar Gracián, Spanish philosopher, seventeenth century²

Variety is the spice of life.

English proverb

In this chapter a first set of crucial concepts of systemic management relating to the environment or situation faced by an organization is laid out – complexity and variety. In addition, the implications of complexity and variety are examined in the light of two fundamental theorems of organizational cybernetics – *Ashby's Law of Requisite Variety* and the *Conant-Ashby Theorem*.

2.1 Two Crucial Concepts: Complexity and Variety

When do we call a matter complex? Complexity is linked to a lack of understanding; it has to do with the multifariousness and uncertainty of an object we have to deal with. A standard definition of complexity is "... the potentiality of a system to assume many different states". It thus becomes necessary to consider three aspects which are fundamental in the context of social systems and organizations, in particular:

1. As it is always observers or actors who are dealing with complexity, the attribute different here is always to be understood in terms of distinguishable.

¹ "I like complexity." (Personal communication, Las Palmas de Gran Canaria, January 12, 2001)

² "Uniformity restricts, variety broadens; the more it multiplies noble perfections, the more sublime it is." (Gracián, 1993/II: Discurso III, Agudeza y Arte de Ingenio)

2. As social systems are dynamic systems, it is not so much discrete states which are of interest, but rather dynamic patterns or *modes of behavior*.
3. When dealing with social systems the potential as well as the current states and modes of behavior have to be considered and the difference between potentiality and actuality is of great importance.

We therefore have to specify that *complexity consists in a large number of distinct (potential or actual) states or modes of behavior*. In principle, the complexity of a system is proportionate to the quantity of (syntactical) information which is necessary a) to describe the system and b) to dispel the uncertainty associated with it (Klir 1991).

Organizational intelligence is intrinsically linked to the ability to deal with *dynamic complexity* effectively, and both these concepts are at the core of *organizational cybernetics*. From a cybernetic viewpoint, management is about ensuring that a system does not assume all potential states or behaviours but only desirable ones. Let us first analyze the role of complexity to get beyond the naive application of that overused catchword.

A technical term to express and measure complexity is *variety* – the number of potential states or behaviors of a system.

Mathematically there are two main formulas in use to calculate variety:

$$\text{Formula I: } V = m \cdot \frac{n \cdot (n-1)}{2}$$

$$\text{Formula II: } V = z^n$$

Codes:

V: Variety

m: number of relationships between each pair of elements

n: number of elements

z: number of potential states for each element

Whichever formula is used, variety always follows a law of power:

It grows exponentially with the number of elements, and if equation I is applied, also with the number of relationships (which are not distinguished in equation II). These formulas are of little practical value except for the sake of visualizing the strength of the variety concept. Even though they are not adequate to calculate dynamic complexity, i.e., variety as the multiplicity of potential behaviors, they give a general idea of the fact that overwhelming complexity is a fundamental issue with which organizations and their managements are confronted.

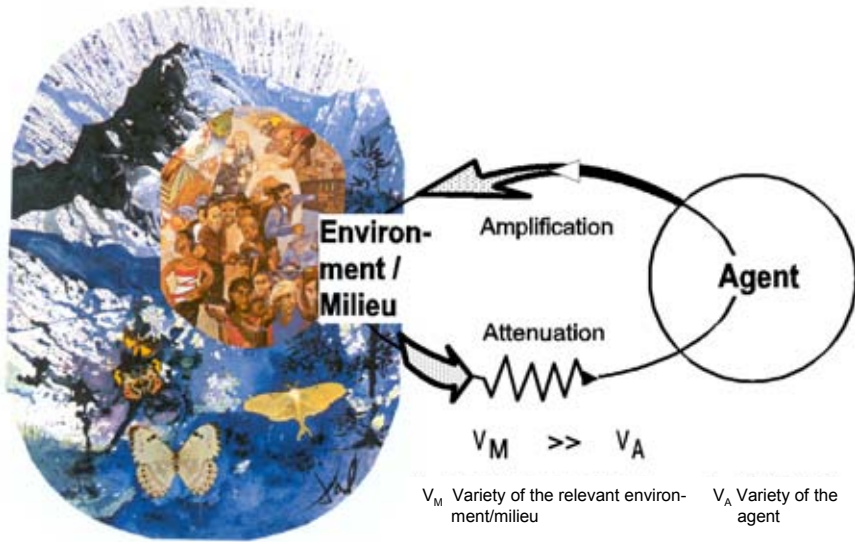


Fig. 2.1 Difference of varieties between an agent and its environment

We have seen that variety is a synonym for “multiplicity”, which expresses the number of different states or modes of behavior a certain system – let us say a company or a market – can adopt. The scheme in Fig. 2.1 makes it clear that an agent – no matter a company, an organizational unit or a manager – is embedded in a relevant environmental milieu, the variety of which by far exceeds the variety of the agent.

Let us take a look at a practical example:

Anyone wishing to entrust a bank with their savings, while not being a capital markets expert, will find it almost impossible to orientate themselves in the bewildering “jungle” of offers. Back in the nineties I visited branches of various different banks to determine whether a different facility than an ordinary bank account would be more advantageous for depositing one’s money. The following experience repeated itself: with a “take it or leave it” attitude the bank clerk confronted me with two or three options a so-called high-interest bank account and perhaps one or two bonds. What I would have wished to see, however, was a simple graph with three dimensions – risk, yield, and social/ecological performance of the companies to be invested in which would have given me an immediate overview of the options available. Nobody was able to show me that. Cybernetically speaking: the variety, in other words the repertory of potential

behaviors of these banks was insufficient to cope with the complexity of the situation at hand.³

In the following two sections the implications of complexity and variety will be examined in the light of two fundamental theorems of organizational cybernetics.

2.2 Ashby's Law of Requisite Variety

The first theorem essential in this context is the Law of Requisite Variety formulated by the eminent cybernetician Ross Ashby:

*Only variety can absorb variety.*⁴

Ashby's law is as fundamental for managers as the laws of thermodynamics are for engineers. It has a cogent implication of enormous bearing: to keep a complex system under control, the control system must dispose of a variety that equals the variety of the system to be controlled.

This statement has often been grossly misunderstood. A host of examples can be found in those organizations which have built up structural complexities that have become unmanageable.⁵ The quest should rather have been to build up *eigen-variety*⁶, in other words, *behavioural repertory*, and to attenuate *foreign* variety, i.e., *complexity of the environment*, as well as to select or create a milieu the organization can cope with.

This latter aspect is crucial in managing complexity: one constantly comes across organizations which have defined their environments in such a way as to confront themselves with completely baffling complexities of their own making, which they are unable to deal with.

The challenge is to balance the *varieties of the interacting systems* through both *attenuation and amplification* (Fig. 2.1). These two complementary approaches are ways of absorbing and generating complexity (variety). The term variety engineering has been used in this context (Beer 1979). The basic strategy here is to attenuate external variety and amplify eigen-variety.

³ A recent survey of the financial-services sector, published in the Economist, suggests that the single incident reported here is an ideal-typical symptom of an industry in crisis, heading for a radical shake-up (Drucker 1999a).

⁴ In the original: "Only variety can *destroy* variety" (Ashby 1956); the verb *absorb* was later introduced by Stafford Beer.

⁵ An impressive practical account of the dynamics of bureaucracy plus an ensuing corporate transformation in a leading company of the chemical industry is analyzed in a detailed case study by Rüeegg-Stürm (2002, Chap. 4).

⁶ "*Eigen*" stands for *own*. "*Eigen-variety*" denotes an agent's or system's own variety.

Are there any heuristic principles for variety engineering? If we consider the formulas for the calculation of variety used above, we can arrive at a notable insight: A complicated strategy does a worse job than an adaptive strategy, which is capable of generating higher variety. The former is a strategy which relies on many *elements* (e.g., agents, people). The latter relies on the richness of the behavioral repertoire of each agent or on a denser network of relationships between the agents.

Let us examine this proposition with the help of the two formulas above:

Formula I: In this case, the two levers of the strategies for complexity generation and absorption are a) the number of *elements* (e.g. agents, people) and b) the number of *relationships* between each pair of elements (e.g., interactions).

If $m_1 = 1$ and $n_1 = 10$, then $V_1 = 45$. If we increase n_1 by one, to $n_2 = 11$, then $V_2 = 55$. The change is $\Delta_{a1} = +22\%$. If, on the other hand, we increase m_1 by one, to $m_2 = 2$, then $V_3 = 90$. The change is $\Delta_{a2} = +100\%$. In other words, the gain of enhancing the relationships of agents is much higher than the gain of adding agents. The leverage of the adaptive strategy, i.e., Δ_{a2} divided by Δ_{a1} , then is 4.5. *Quod erat demonstrandum (QED)*.

Formula II: In this case, the two levers of the strategies for complexity generation and absorption are a) the number of *elements* (e.g., agents, people) and b) the number of *states* each element can assume (e.g., distinct behaviors).

If $z_1 = 2$ and $n_1 = 10$, then $V_1 = 1,024$. If we increase n_1 by one, to $n_2 = 11$, then $V_2 = 2,048$. The change is $\Delta_{b1} = 100\%$. If, on the other hand, we increase z_1 by one, to $z_2 = 3$, then $V_4 = 59,049$. The change is $\Delta_{b2} = 5,667\%$. In this case, the leverage of the adaptive strategy is 56.7. Of special interest here is the fact, that if $z = 3$, then it would be enough to have seven agents to achieve a variety of $V_5 = 2,187$. That is, V_5 would even exceed V_2 , even though the former had 11 and the latter only seven agents. *QED*.

The varieties would explode far beyond the numbers in these examples, if we would proceed with a dynamization of this calculus.⁷ This would entail much higher numbers, ultimately absurdly huge numbers, which – for our purpose – would not convey additional insights.

Summing up, adaptive strategies are more effective than complicated strategies of variety engineering. They are based on enhancing the repertoire of behavior of the agents or on strengthening their network of relationships.

⁷ For an example, see Beer (1966, 250ff).

At this stage, one must add that a social system is not primarily subject to exogenous control but that it regulates and steers itself to a great extent. In other words, most of the complexity absorption takes place within the systems, not between them. These forces of self-organization must be purposefully leveraged. The management of a company need not be confronted with the totality of problems occurring inside the organization because most of them can be solved autonomously within the subsystems. Management is only supposed to face the residual variety, i.e., those issues which cannot be brought under control by these subsystems themselves (Fig. 2.2⁸). The same applies to the relationship between an organization and the environment. I instance the case of an insurance company that can shield itself against the bulk of the market's complexity thanks to a network of insurance agents which efficiently absorbs that variety. The company can then concentrate on designing products and on honing its informational and financial skills.

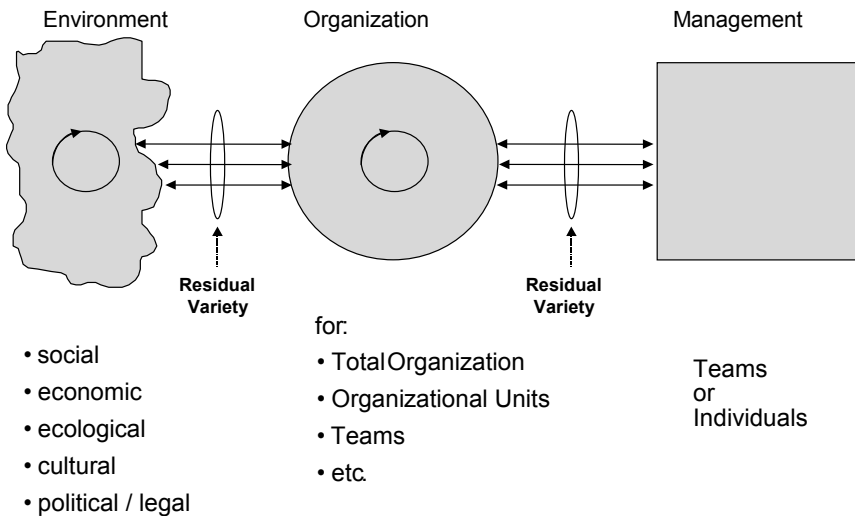


Fig. 2.2 How organizations and their managements cope with complexity

The design of organizations can essentially revert to three types of amplifiers and attenuators, cognitive, structural and interactive/conversational ones:

- *Structural*: e.g., segmentation of the market and concentration of forces to build up behavioral repertory, differentiation, modularization, redundancy,

⁸ The concept of Residual Variety goes back to Espejo (1989a).

decentralization and autonomy as well as all manner of constraints (norms, rules, conditions, values), which can absorb complexity.

- *Conversational/interactive*: e.g., solving problems in teams, discursive approach to strategy formation etc.
- *Cognitive*: these are the sensory organs and the perception as well as the information system by means of which vital signs are perpetually filtered out from the flow of events.

The strongest cognitive attenuators of variety are prejudice and ignorance, but they are counterproductive in the longer run. In other words: functional and dysfunctional attenuators and amplifiers can be clearly distinguished. This applies also to the domain of knowledge. Even tacit knowledge, which bestsellers have offered as a panacea, can be right or it can be wrong. The decisive factor is the quality of the mental models, in other words that the right questions are posed at all levels. This leads us to the second theorem, which I have to introduce with a set of theses.

The image of the effective manager is by and large linked to the idea of rapid decision making. However, many decisions neither become better when they are taken faster nor can they improve the situation significantly.

Studies carried out at the Strategic Planning Institute show that the performance of companies only hinges on operative decisions by 20%, on skilled tactics by 10%, while strategy “determines” 70% (Buzzell and Gale 1987). Here is my consequent first thesis:

It is less important to decide quickly than to recognize the need for decisions in good time.

The quality of a decision depends essentially on recognizing at an early stage which events and especially changes are relevant. The crucial aspect here is the aptness of the orientators to assess a state of affairs on the basis of which a management body decides and acts. For example only a more recent development in management theories has shown that profit, with its components of revenue and costs, is an inherently short-term indicator. It is inadequate to orientate the evaluation of strategically relevant matters. To do that it is necessary to look at those factors which *pre-control* profit. This is the reason why time management should primarily rely above all on starting earlier, and not on merely acting (or reacting) faster and therefore even hectically or prematurely.

This leads to my second thesis:

The quality of a decision depends less on the supply of data than on the demand for information.

The main problem is not the availability of data, but the model (or scheme) which directs an inquiry. Technology has eliminated space- and time-related

restrictions to data procurement. The edge now is in recognizing the relevant orientators in time and in articulating the need for relevant information. Very often the adequate data are available within the company itself but remain unexplored because their relevance is not seen.

Therefore, my third thesis (following Ackoff 1967):

Managers suffer less from a lack of relevant data than from an excess of irrelevant data.

In this context it is necessary to draw an important distinction which has hitherto been widely unheeded: The concepts of “data” and “information” are often used synonymously. Distinct from the technical concept of information by Shannon and Weaver, cybernetics uses the following helpful grading (after Beer 1979):

1. *Facts*: Whatever is the case.
2. *Data*: Statements about facts.
3. *Information*: What changes us.

Between making data available and generating information lies a kind of quantum leap: making out the difference between what is irrelevant and what is relevant. Bateson (1973) defines information as “a difference which makes the difference”.⁹

Hence information implies an insight which may trigger a change. Therefore, information always emerges within a recipient, as we know from communication theory. Naturally, relevance is often only discerned once an exchange with others has occurred; therefore: discourse between different perspectives is essential (this could be a thesis 4).

In this context, three further concepts are of importance (Schwaninger 1998a):

4. *Knowledge*: Generally speaking, “knowledge is whatever is known – the body of truth, information and principles acquired” (Longman 1982, p. 768) by some subject on some subject. Knowledge, therefore, is always embodied in somebody.¹⁰

Knowledge implies insights, which enable orientation; in other words, knowledge can be conceived of as action potential. This is closely linked to learning – enhancing one’s potential for effective action (Kim 1993). Learning, by this account, is the process of developing and grounding knowledge. When we are able to use information in an action domain, then

⁹ These cybernetic definitions of “information” already imply the semantic dimension of meaning attached to a signal by the one who receives it.

¹⁰ The corollary to calling some data or even rules stored in a medium “knowledge” is to confuse reading the recipe for a dish in a cookbook with eating that dish.

we start to know. When we can transform that knowledge into effective action, we have reached the point of understanding something.

5. Understanding: Understanding is in-depth knowledge, involving deep insights into patterns of relationships generating the behavior of a system. Understanding is often referred to as the “knowledge of masters”. It implies the capability of conveying subject knowledge to others. However, we do not define understanding as knowing every detail about a complex system (this would be a faculty both impossible to acquire and useless to possess).
6. Wisdom: By wisdom we mean a higher quality of knowledge and understanding, implying the ethical and aesthetic dimensions of knowledge. We can even go so far as to state that true wisdom is so constituted that it brings about the good, the true and the beautiful. Wisdom is accessible to those who struggle for it. Anyone can and should strive for it.

As we advance from data to wisdom our action potential increases. This is schematically represented in Fig. 2.3.

Action potential

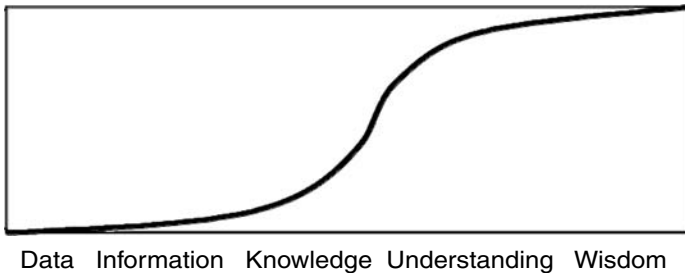


Fig. 2.3 The growth in action potential from data to knowledge to wisdom

The traditional scientific mode of inquiry relies on *analysis* – taking a system apart and studying the components and their behavior. This produces knowledge but not in a such way that the behavior of a complex system could be explained or understood. For that purpose *synthesis* is required – putting the pieces together, looking at the whole and its function in the larger system (Ackoff 1999a). Systemic thinking uses both, analysis and synthesis as complementary modes of the process of inquiry.

2.3 The Conant-Ashby Theorem: Models are Crucial

Organizations continuously receive messages or signals about events for which they do not possess a schema enabling them to be informed of the relevant facts. Whatever the importance of such messages might be for their viability, they remain unheard and therefore dissipate.

This leads us to the vital importance of the models (or schemes) on which those responsible rely and so to our second law: the Conant-Ashby Theorem (Conant and Ashby 1981). This derives directly from the Law of Requisite Variety and states:

Every good regulator of a system must be a model of that system.

In other words: the result of an organizational process can not be better than the model on which the management of that process is based, except by chance.

This proposition contradicts commonplace “knowledge”, which often claims that management models are a thing of the past, usually with the explanation “that today everything changes so fast”. Arguments of this kind fail to consider that all managerial activity is based on models, whether the respective agents are aware of them or not. In the light of the Conant-Ashby Theorem most of the more or less trivial recipes given by current bestsellers on management must be dismissed as insufficient and even dangerous.

The fact that many or even most organizations are still managed on the basis of inadequate models is a serious problem. The traditional models of management are dominantly oriented towards profitability. The ROI (Return-On-Investment) – based system of indicators¹¹ is well-proven but insufficient because in the context of rapid change profit rates are inadequate as a means of measuring the performance of an organization. Basically, they are not much more than short-term and partial indicators of the success of a business. “Shareholder value” is a term which, in principle, is supposed to reflect longer term aspects, too, namely the anticipated evolution of a business or firm. In practice, however, the shareholder value estimates are strongly determined by projections or extrapolations of sales, cost and profit figures.

These models lack the requisite variety. Relying on them is therefore likely to be misleading; they might point in precisely the wrong direction. The following analogy is useful: assessing the effectiveness of a business by the level of its profits is like measuring the temperature to decide the current season of the year. However, for this purpose, the calendar, not the

¹¹ Originally this system of indicators became famous as the “Du Pont Scheme”.

thermometer would be the appropriate source of information. Long-term patterns originate from different causal mechanisms which double-entry bookkeeping is unable to ascertain. It is essential to make this point in the face of the current frenzy about “management by financial figures” whereby short-term thinking tends to drive out long-term orientation.

These critical remarks are not meant to cast doubt upon the relevance of profits as such. In the long run no company can survive without being profitable. Profits are a prerequisite to realize investments and to maintain the substance of a firm. In Peter Drucker’s precise though paradoxical words, profits are “the cost of staying in business” (Drucker 1980). But if profits are necessary for the survival of a company, profit mindedness is not apt to ensure its viability and development. On the contrary, the oft referred to goal of profit maximization is a hindrance rather than a help towards acquiring greater organizational intelligence.

It must be conceded, however, that a number of efforts during the nineties have bred new initiatives to overcome this narrowness of control models. Management accounting has generated multidimensional sets of indicators to measure and control organizational performance. A much discussed approach is the Balanced Scorecard, which is aimed at balancing different aspects of control, e.g., market, process, finance, development (see Kaplan and Norton 1996). It must be observed that this instrument is much less widespread than one might expect.¹² Other efforts try to include the social and ecological perspectives into all aspects of management, control and auditing in particular. However, much of this effort is still superficial (cf. Sharma and Henriques 2005) and lacking in solid theoretical foundations.

Another issue of concern is related to the models for organization design which are in use today. They are manifold and often contradictory. Much of what is advocated reflects the latest fashions, mostly developed on pragmatic grounds. But the theoretical basis of these models is in general weak thus limiting their practical effectiveness.

This has to do mainly with two developmental patterns widely in use. One is the inclination of consultants to propose a model which either

¹² “Research suggests that 60% of Fortune 1000 companies have experimented with the BSC and data from the Gartner Group suggest that over 50% of large US firms had adopted the BSC by the end of 2000” (Kaplan 2003). From a sample of the 200 largest German corporations, 46% of the responding 129 companies indicated that they made use of the Balanced Scorecard (Price Waterhouse 2001). In one non-representative sample, equally from Germany, 58% of the responding 33 firms used or planned to use the Balanced Scorecard (Abel 2001). According to a survey from Denmark, answered by 59 companies, the level of knowledge about the Balanced Scorecard appears to be high, about 80%, whereas less than 20% give a high priority to the BSC. Only 4% of the respondents claim full use, 28% partial use of the BSC (Nielsen and Sorensen 2004).

reflects the insights from a limited number of experiences made, or is based on hypotheses which have not been extensively corroborated. To overcome this deficiency, academic researchers adopt the second mode, i.e., empirically based theory building. Their hypotheses are often thoroughly tested, but they are usually very limited in their relevance. Furthermore, the theoretical reasoning on which they are based necessarily tends to extrapolate conventional theories. A new strain of theorizing seldom emerges from the mainstream academic journals.

A final issue of concern is related to the fact that most of the models in use rely on discrete and rather static pictures of organizational reality, in spite of the necessity to understand the patterns of behavior generated by those organizations in the mid- and long-term.

In the following chapters of this book, newer and more powerful models will be expounded which promise a much higher potential for coping with dynamic complexity effectively than the established ones criticized here.

Even though the models that will be addressed in the different chapters (especially 5, 6 and 7) are specific as to their purpose and capabilities, in this book models are conceived in a broad sense. Discussion of models in general, as in this chapter, includes not only formal models and mental models; *frame(work)s*, *schemes*, *philosophies*, *mindsets* and *paradigms* may also be subsumed under this term.

Models confine and they enable. It is our models which “determine”, to a large extent, what our future realities will be like. I write *determine* in italics because organizations are not deterministic, like commonplace, trivial machines (von Foerster 1984a). Social and human actors are non-trivial, i.e., they do not respond algorithmically to stimuli or conditions. They pursue ideals, ends, objectives, and have preferences and values, all of which may change. They make choices. They are able to invent new solutions and come up with different modes of behavior. That is why the management models to be presented here are of a *heuristic*, not an *algorithmic* kind.¹³

¹³ A heuristic (from the Greek word *heuriskein* – to discover) is a set of method-ological instructions for the solution of problems or for an exploration to find new insights. The goal may be unknown; progress is continually or repeatedly assessed according to known criteria (Cf. Beer 1981, p. 402). An algorithm (from *al-Khuwarizmi*, Arab mathematician) is a systematic procedure for the solution of a mathematical problem in a finite sequence of precisely defined steps.



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Intelligent Organizations
Powerful Models for Systemic Management
Schwaninger, M.
2009, XII, 229 p., Hardcover
ISBN: 978-3-540-85161-5