

## Presidential Address

**Donald C.A. Hector**

The Royal Society of NSW  
Email: dchector@royalsoc.org.au

### Abstract

Donald Hector AM was President of the Royal Society of NSW from 2012 to 2016. In an address marking the conclusion of his presidency, immediately following the annual general meeting of the Society on Wednesday, 6 April 2016, he considered the nature of the complex problems that face 21st-century Australia, the way in which people tend to approach these highly-complex socio-techno problems and the cognitive and cultural limitations they have in identifying solutions. In particular, he considered the role that the Royal Society of NSW might play as it is re-established as a leader in the intellectual life of NSW and of the country.

For many years, it was a practice of the Society for the President to deliver an address at the conclusion of the presidential term. This custom fell into disuse in recent years but with the change to the rules and bylaws last year, it was decided to reintroduce it.

My aim tonight is not to reflect on the activities of the Society in the last four years, other than in passing—rather, it is to attempt to chart a way for the Society as it re-establishes itself as an intellectual force in New South Wales and the country. So I shall limit my comments on the recent history to these.

By far the most successful development in the last several years has been the establishment of the category of Fellow and the elevation of the former Fellows to Distinguished Fellowship. This raised considerable interest in the activities of the Society and we were fortunate that very capable people indeed have accepted the invitation to Fellowship and that some of them have become involved in the activities of the Society and its governance. We expect that this will continue and that we will see sustained growth in all membership categories. But this will

only be the case if the activities of the Society are considered to be making a valuable contribution to the public discourse. How might we do this?

In September last year, for the first time, the Society organised a forum with the four Australian learned Academies. One of the outcomes of the meeting was a list of major challenges and issues where the Society could contribute, taking a transdisciplinary approach across art, science, literature and philosophy. Of the issues identified at the forum, one common characteristic they shared was that they are all highly-complex, socio-techno-economic problems. Most of these are not limited to NSW nor to Australia—in many cases, they are global issues. I would like to spend the remainder of my address exploring how these complex problems have come to be, why we see them in the way we do and what we can do to contribute to a solution. I will take a historical perspective and consider some issues around philosophy and cognitive psychology that I believe are important in framing these problems and identifying solutions.

The way in which all animals interact and survive in their environment is through solv-

ing problems. Humans have developed a remarkable capacity for intellectualising problems and solving them in the abstract. Some of these problems can be simply stated and have simple solutions—for example, will I catch the bus to work this morning or will I ride a bicycle? At the other end of the spectrum, there are many problems that can be both difficult to articulate and to resolve. Contemporary examples of these are: what are we to do about climate change? or how can we provide a cost-effective health system? I would like to briefly explore the nature of problems and why some of them are so difficult to understand and to solve.

The way in which we define and attempt to solve problems today has its origins in the philosophy of ancient Greece. Indeed, the rediscovery of classical philosophy in the 13th and 14th centuries was a major influence on the Renaissance. Let me refer to an example. Many of you will have seen this painting or be familiar with it. It was painted by Raphael in 1509 and is a fresco in the Apostolic Palace in the Vatican. It is widely considered as one of the finest pieces of art from the Renaissance. It is usually referred to as *The School of Athens* (although its formal name is *Knowledge of Causes*).



*The School of Athens*

The two central figures are Plato and Aristotle but other Greek philosophers (Socrates and Diogenes) are also represented, as are other philosophical influences from the pre-Christian era. I will refer to this painting again later to make some other points but what the painting shows is the influ-

ence of philosophy in Renaissance thinking. It is intended to represent natural truth as acquired through reason, arithmetic, geometry, astronomy, rhetoric and dialectic and also represents art, music and poetry.

On the opposing wall is a second painting, also by Raphael, called *Disputation over*

*the Most Holy Sacrament.* It was painted the following year and shows God the Father looking down on the resurrected Christ who is flanked by the Virgin Mary and John the

Baptist and prophets and saints of the old and new Testaments. Beneath are Popes, saints and the faithful masses and with Aristotle, head slightly bowed and his books on the ground.



*Disputation over the Most Holy Sacrament*

On the one side of the chamber, is a representation of knowledge and reason; on the other, the realm of God. In many respects, these two juxtaposed paintings represent the thinking and belief-system of that era and upon which the Renaissance developed. Art can give great insight into human thought — let us explore this notion a little further.

Consider this example of ancient Greek art. It is from a piece of pottery of an uncertain date and is thought to represent Euripides' *Medea*. Its composition is what Paul



*A piece of Greek pottery of an uncertain date and is thought to represent Euripides' Medea.*



Feyerabend (1975) refers to as a “paratactic aggregate” — a specially-structured group of individual elements. Feyerabend suggested that this shows that Greek thought was elemental in nature — they believed that that everything in the world consisted of atoms that were aggregated into bigger and bigger things.

The story is told by the relationship of the elements in the artwork. Another characteristic of Greek art was that it had no perspective. Together, this suggests that Greek thought was not developed into an integra-

tive, representation of the world and that the sense of perspective that is important in modern representations simply had not yet developed. This notion is reinforced by the nature of the ancient Greek language. It is also paratactic — it depends heavily on structure. Their thinking — the paradigms they used — were, perhaps, elemental, mechanistic and lacking in perceptual depth.

Now let us move to the very early Renaissance — about 1350. Consider the fresco in Campo Santo, Pisa, by Francesco Traini, called *Triumph of Death*.



*Fresco in Campo Santo, Pisa, by Francesco Traini, Triumph of Death.*

There is much similarity between the style of Greek art and this painting; there is no perspective and the story is told by structure of the elements represented in the painting. Let us now go forward about 100 years to 1430 — this is a scene painted by Paolo Uccello representing Mary approaching a temple. In the space of 100 years or so, perspective has started to emerge, giving a sense of depth and three-dimensionality. The style is more integrative, with the characters becoming part of the scene, rather than simply arranged in it.

Now let us return to our painting by Raphael, *The School of Athens*. Painted 70 years later, in 1509, and at the height of the Renaissance, the style is entirely different. It is much more fully developed: perspective is clear — it is a representation of a three-dimensional scene that truly appears to be in three dimensions. Everything is integrated: the various philosophers and thinkers are engaged in conversation with each other (even though some are from different eras). It tells a story.



*A scene by Paolo Uccello representing Mary approaching a temple.*

What I have tried to show here are some of the foundational influences on the Western way of thought, as represented through its art. Whether or not Feyerabend's theory is correct is open to discussion but it is hard to accept as coincidental the extraordinary development in the sophistication of artistic representation that happened at the same time as the development of philosophical thought in centres such as Florence and Padua. As the influence of the Renaissance moved from Italy across Europe, the centre of intellectual thought gravitated towards Holland, to (what is now) Germany and to England. The discoveries and thinking of Copernicus, Galileo, Bacon, Locke and Newton, based on Greek philosophy, continued to develop within the mechanistic Greek paradigm — the universe was like a great machine overseen by God. This thinking prevailed until the 18th century when philosophers such as Kant and Hegel brought different perspectives to our interpretation of reality and the “interconnectedness” of everything in the universe. Nonetheless, the mechanistic paradigm persisted until the late 19th century. At about this time, biology and ecology began to develop and the mechanistic paradigm was insufficient to

explain many of the phenomena that were now being observed. A new model emerged for explaining these — systems theory.

Mechanisms, like clocks, behave linearly — a disturbance to the mechanism produces an effect in proportion to the disturbance. The analytical technique developed in Padua in the mid-Renaissance works very well. If you have a problem, disassemble it into its component parts, solve the component problems and synthesise a solution to the original problem from these. But systems do not work this way. They are non-linear — a tiny disturbance in one part of the system can result in a surprisingly large disturbance in another. Systems can appear to be stable but a small disturbance can introduce major instability — they can flip. They are characterised by subsystems whose behaviour interacts with other subsystems to influence the behaviour of the whole — you cannot predict the outcome by simply adding the subsystem responses together. At the heart of systems theory is that everything in the universe influences everything else. Systems theory and its underlying philosophy of interconnectedness and uncertainty was remarkably successful as a means to understand an enormous array of phenomena from the behaviour of ecosystems, to quantum mechanics, to biological systems to the behaviour of high-speed aircraft and the control of equipment in power stations and other industrial processes.

After the Second World War, there was massive rebuilding and restructuring of society. New problems started to emerge: how to provide healthcare, establishing effective educational systems, trying to make sense of economics to avoid catastrophes such as the Great Depression and deal with ever-increasing environmental damage. Advanced

mathematical techniques such as linear programming, game theory, queueing theory, marginal analysis and information theory were developed as a consequence of militarisation, in particular strategic analysis as the Cold War deepened. But these were generally unsuccessful in solving this new class of problem. They were variously described as “messes” and “wicked problems”. Generally, there was no shortage of data to draw upon

to characterise the problem. But the systems nature of these problems were surprisingly resistant to analytical approaches. Typically, these problems had social dimensions that were difficult model.

Summarising, over the last 500–600 years the way in which problems are identified in characterised has evolved substantially. We now think of problems in three broad types:

PROBLEM TYPE	CHARACTERISTICS
Simple Problems (or mechanistic or scientific problem)	Problems that can be represented using a mechanistic model and resolved using the reductionist approach.
Single-Dimensional Complex Problems (or technical or systems problem)	Problems—often of a technological nature—that can be represented on one problem dimension.
Multi-Dimensional Techno-Societal Problems	Problems that can only be represented on multiple dimensions, considering issues such as moral status, intrinsic character, value, beliefs, aesthetics etc.

*Table 1: Increasing problem complexity*

But there is another dimension to problem-solving: the “domain of interests”: that is, the people or stakeholder groups involved in either the problem itself or any solution that might be identified. The domain of interests can range from a single individual trying to solve a simple problem up to highly complex, global problems whose domain of interest extends across species and ecosystems. One might conceive of three broad domains of interest: unitary; pluralist; and disparate.

A unitary domain exists where there is a single decision-maker or, if there is more than one individual, where the decision-makers have a shared worldview and an agreed determination in resolving the problem. A pluralist domain is one where there is a shared determination to problem resolution but there are differing worldviews among the stakeholders. Issues of power

and coercion are either explicitly or implicitly set aside. And a disparate domain of interests is where there are major differences in underlying beliefs and values among the stakeholders. The worldviews represented in the domain may be in open conflict. There may not even be agreement that a problem exists or that action needs to be taken. There may be distrust among stakeholders and there may be deliberate use of power to coerce or frustrate problem definition and decision-making. These three domains are represented in table 2.

Taking these two dimensions of problem structure together, three fundamental types of problem can be identified as shown in diagram 1:

**Type 1:** these are problems which normally yield to reductionist or systems-analysis problem-solving approach. Traditional

DOMAIN OF INTERESTS	CHARACTERISTICS
Unitary	A single decision-maker or a group of decision-makers and other stakeholders which have the same interests and similar worldviews.
Pluralist	Decision-making interests are largely aligned but there may be many different worldviews among stakeholders. However, they share the same determination or interest in arriving at a satisfactory problem resolution. Power is equally shared among constituents or, because of the shared determination to resolve the problem, issues of power are set aside.
Disparate	There are major differences in underlying beliefs and values and the interests of stakeholders may differ widely. There may be a lack of shared determination to resolve the problem, distrust of the motives and intentions of other interests, and even specific intention not to see the situation resolved and to derail attempts to agree upon the problem definition or efforts to proceed. There may also be significant power imbalances among the constituents and these are used coercively.

*Table 2: A further dimension of problem complexity—the Domain of Interests*

scientific and engineering methodologies can be applied such as mathematical modelling and computer simulation.

**Type 2:** these problems which due to their complexity and systems nature require a combination of reductionist, analytical and hard- and soft-systems analysis approaches.

**Type 3:** these problems are often unique and always highly complex—this precludes or severely limits the use of traditional scientific, engineering and systems analysis approaches. Human stakeholders hold apparently irreconcilable differences in beliefs and values and are more than willing to exploit power imbalances coercively to achieve their own ends. Moral status of stakeholders and their interests may be difficult to identify and some (for example, non-human species) may not be formally represented in the decision-making domain.

This characterisation of Type 3 problems that has emerged over the last half century or so is not unique nor is it particularly new. These “wicked problems” or “messes” and have occupied the thoughts of operational researchers for many years but with only limited success. But what is different here is the representation of these problems on two dimensions—recognising that the influence of differing worldviews and the coercive use of power has enormous influence both on characterising the problem and moving towards some resolution. An important point to note is that describing or structuring the problem is fundamentally a human, social construct. Worldviews and belief-systems are at the heart of both defining and solving problems.

Let me summarise my argument so far.

As the humans have evolved, so too has the way in which we conceive of and attempt to solve problems. The worldview of the ancient Greeks persisted for well over a millennium. But in just a couple of hundred

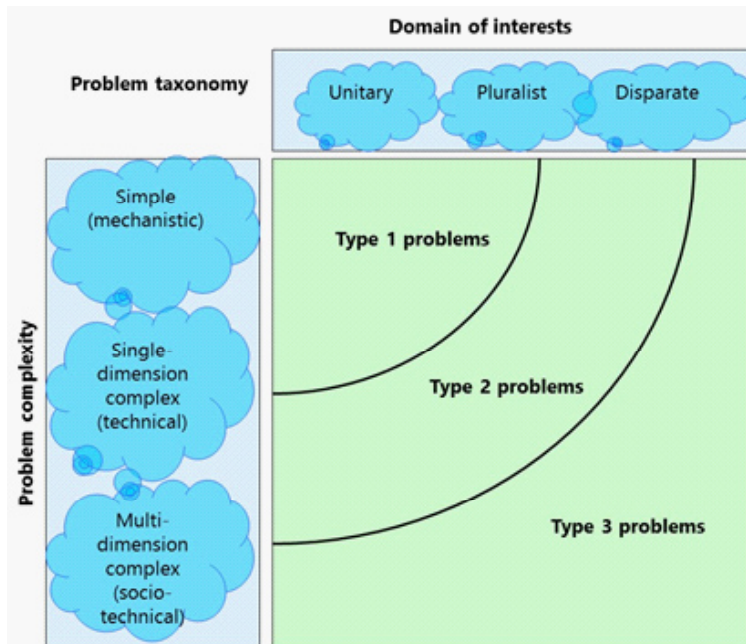


Diagram 1—problem taxonomy.

years, the Renaissance brought a dramatic change in the Western world—there was a flourishing of thought and a number of different philosophical approaches emerged. But as population and social complexity increased, so too did the complexity of the problems that confront us. Not only are the technical aspects of the problems challenging but they are further complicated by the divergence in worldviews that occurred. In the last century or so, social and cultural influences in an increasingly liberal society have added another dimension to the way in which we need to consider complex problems. The second dimension of problem structure that I have proposed here is predominantly about influence and power and is a major obstacle in solving the highly complex socio-economic problems.

Before exploring how these types of problems might be addressed, I would like to take a brief diversion to outline the philosophi-

cal framework upon which Anglo-American society (by which I mean the various countries around the world that emerged from or were strongly influenced by Britain) has developed in the period since the late 16th century. I confine my remarks to the Anglo-American philosophical framework because Royal Societies around the world are creatures of this. It has also been very influential in the development of the modern era. Time does not permit a detailed examination of these, so I will just outline them briefly.

What was originally called “philosophy” and has evolved into scientific enquiry is dependent on the scientific method of conjecture and refutation. It is founded on a rationalist philosophy and traces its origins to thinkers such as Bacon, Locke and Newton. One of the principles of rationalism is that we can acquire knowledge in two ways: one is empiricist (interpreting knowledge that we acquire through our senses); and the other is



intuitive and deductive (there is some knowledge that we can acquire through thought and deduction alone—mathematics being an example). It is oversimplifying somewhat to say that scientific enquiry is entirely rationalist—there are many factors that influence it, including sociological ones. But its intention is to converge upon some notion of truth through rigorous, intellectual enquiry.

Political and social institutions are generally framed on different philosophical principles—they are utilitarian. Utilitarianism originates with Bentham and Mill and has been developed by many others. Its original concept was that a “good” act is one that maximises pleasure. Unlike rationalism, it is less concerned about finding truth; rather it is a normative ethical system—it attempts to define a set of rules for society to live by. Over the last couple of hundred years, “pleasure” has been replaced with “benefit” or, more recently, “happiness”. Most economic analysis is utilitarian in its nature: what will deliver the maximum benefit for the minimum cost? Similarly, our political systems attempt to arrive at maximising public good (or happiness) with minimum interference with individual liberty—they are fundamentally utilitarian, liberal frameworks.

Legal institutions are different again. They are also based on normative philosophical principles but are framed around deontological or duty-based ethics. One particularly influential philosopher in this area was Kant who argued that a “good” act is one in which one does one’s duty. Duty can be defined in terms of a legal code or duties that emanate from moral good. Kantian ethics is controversial but nonetheless the British legal system is largely duty-based system. (For example, sections 180 to 183 of the Corporations Act defines duties that must be observed by company directors.)

So, the society in which we find ourselves today is largely the product of three philosophical systems that are becoming evermore influential and, in many aspects, are replacing the influence of religion that until relatively recently dominated our value-systems. The extent to which belief (whether religious or humanist or some other value-based system) influences decision-making is of critical importance in solving the highly-complex Type 3 problems that prove so challenging.

I will now briefly explore some cognitive psychology in an attempt to identify the way in which these Type 3 problems might be addressed. There is a large body of literature in cognitive psychology relating to problem-solving originating, in the 1920s and 1930s. I will confine myself just to drawing a few points from this literature.

One of the key researchers in this area was Hammond (1955) who integrated the work of a number of eminent psychologists relating to the way in which people respond to cues that they receive. Researchers found that people form judgements and make inferences based on observations that are weighted according to their experience and other subjective influences. The analogy of the “lens model” was created—just as light is distorted by an optical lens, giving different images to different observers depending on their position, so too do individuals involved in a complex situation form different perceptions of the problem and the path forward. Hence, there can be no objectively-determined understanding of complex problems.

In a ground-breaking piece of work in the 1950s, Miller (1955) found that people have a very limited capacity to retain pieces of information in their minds (somewhere between five and eight pieces of information

at any one time) but an extraordinary capacity to recall information to mind to process it. Another related body of research by Boulding found that people form “images” or mental representations of situations that are important in the way in which they reach decisions. They imagine what the future might be and then strategise to achieve it. These images are not simply mental pictures, rather they are complex mental representations of situations that we are attempting to understand. An interesting example of this is the “cognitive map” that we form to help us relate to our situation in the physical world—not only is it a locational map, it is a representation of self and our relationship with the physical world. This fundamental cognitive process probably underlies the human penchant for representing complex information in a wide range of graphical and visual formats, such as maps.

Many of these mental phenomena are not specific to humans—all cognisant animals seem to utilise them. It is how cognisant beings deal with the enormous complexity of the world in which they find themselves. The complexity is too great to comprehend, so a form of thinking—intuitive thought—evolved to make sense of it. At some point our evolution, humans developed the capacity for rational thinking. It is the capacity for rational thought that makes humans sapient (some other animals appear to possess limited capacity for rational thought but there is none that comes close to humans). But the capacity for rational thought is bounded—the world is far too complex for the human mind to comprehend it completely.

On one hand, intuitive thought is used by all cognisant animals. It is instinctive and quick and the main mechanism by which we

survive. On the other, rational thought is largely peculiar to humans. It is slow, deliberate and it is learnt. In the 1970s and 1980s, work by Tversky and Kahneman (1974) and others found that intuitive thought is subject to a range of biases and that these have a significant impact on the success of decision-making. Rational thought (or least some of the means to it) can be taught and improved but it is error-prone. Whereas intuition is subject to bias, rational thought is subject to error.

But we need to put these mental representations and processes into a both a chronological and cultural context. This requires another cognitive device—the narrative.

Narrative and story-telling is as old as humanity itself. It predates writing and occurs in every human society and culture. Throughout most of history, story-telling has been the principal means by which knowledge is transferred from one generation to the next. There are various theories of narrative but they share some common characteristics. They are always about people or things and a group of characters forms part of the thread that holds the narrative together. They are developed against an explicit set of values or a moral standard against which the actions in the narrative can be evaluated. Until the 1970s, narrative was thought to be simply a cultural artefact, but now it is considered to be a fundamental cognitive process. While cognitive maps provide the three-dimensional framework that we use to relate to the real world, narrative adds the fourth dimension—time. It also provides the means to fill in the gaps in our understanding and to make our mental representation coherent with our experience and our worldview. In other words, we make things up—we confabulate—to fill in the gaps in our knowledge and most importantly,

in order to make our representation of the problem conform with our belief-system.

So, let me summarise these few fragments of psychology. No two individuals see a problem in exactly the same way—we are all looking at things through “lenses” that distort our view of reality according to our perceptions and experience. We form images of problem situations that are heavily influenced by our philosophical framework and belief-system. Our immediate response to problems is intuitive but this is subject to bias. A more measured analytical approach—rational thought—can be learnt but we must remain aware that we can make mistakes. These two thought processes have been described as two different systems but that misunderstands the fundamental nature of cognition—they are a single system responding to different stimuli and this system exhibits all the non-linear and unexpected characteristics that one would expect. In order to make sense of the enormous complexity we encounter, we confabulate to make sense of things that we do not understand to make them conform to our notions of reality.

So how might we move forward?

Recognising the enormous human creativity available to us through combining our capacity for intuitive and rational thought, we can use the enormous body of knowledge (that continues to grow at an exponentially rate) and our capacity for rational analysis to gain much greater insight into problems that were previously unassailable. We can imagine what futures might look like. If we remain conscious of the bias associated with intuition and alert to the ever-present chance of error with rational thought, we can reduce the chance of serious mistakes. Recognising the systems nature of cognition, we can harness both intuitive and rational

thought to bring great creativity. Because we can recognise that various stakeholders in situations will approach the problem from different perspectives, we can accept this as fundamental to the human condition and that should facilitate understanding. The big challenge is to embrace the complexity of the problem—particularly the sociological dimensions—to overcome the inherent bias that we all hold to find common ground, rather than focus on the differences.

Most importantly, we can write narratives. Drawing upon our diverse experience, these narratives can engage people with a wide range of worldviews and draw them along with us.

And now I come to my final point. The Royal Society of NSW is uniquely placed to provide leadership in this type of complex analysis. The wisdom of the founders in defining such a broad remit of human knowledge—science, art, literature and philosophy—was truly prescient and recognised the ever-increasing complexity of modern life. But we need to change if we are to maximise our impact. Historically, the Society has focused on the sciences: in its early days, the physical sciences—physics, chemistry and geology—and, later, zoology, botany and biology. Only recently, have we extended into the other areas of human knowledge encompassed by our charter. We need to attract Fellows and Members from all fields of human knowledge, if we are to engage in the representation and solution of Type 3 problems. We need more writers, artists, sociologists, musicians and historians. Only then, will we be able to completely engage with the community. That is not to say that we should abandon our scientific heritage—quite the opposite, most of the problems that the world faces today have enormous technological challenges. But

these solutions will not be found in science and technology alone — they will require the engagement of non-scientists in terms they can understand.

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Donald Hector AM was President of the Society from 2012 to 2016.

