Towards Grasping the Unknowable: Networked Hierarchies of Analogies

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Abstract:

This paper investigates the purposeful use of analogy in teaching and learning rather than how analogy works as a neuro-cognitive activity. Nonetheless, we shall make some reference to mental processing in order to support our proposals. The use of the word purposeful in this context is taken to mean that analogies are educationally most fruitful in specific contexts. Further, it assumes that an analogy has an optimal potency, which diminishes or increases in relation to complexity and relevance. In turn, this suggests that analogies have inherent disposability, or rather, we suggest, a range of references or applicability. We discuss the notion of a hierarchy of disparate analogies to describe a single instance or event and conclude that because of the capacity to move non-linearly amongst analogies, it is more profitable to refer to a network of analogies that allow specifically purposeful understandings of a fundamentally unknowable concept. In conclusion we suggest that the cognitive strategy that drives the movement within the network is contextually-bound functionalism.

Keywords:
Analogy, Networks, Cognitive Strategies.

Science educator Steven Jay Gould proposed that the common denominator of genius includes a breadth of interest and the ability to construct fruitful analogies between fields (Gould, 1980; p 57). We suggest that a strength of Gould’s proposition lies in the dynamic relationship between a breadth of interest and analogies that fruitfully cross domains of knowledge. It is the process of domains of knowledge expanding and dispersing into more specific domains and the process of creating links between domains that allow us to propose new understandings of previously opaque concepts. For the most part the latter process involves the creation of analogies.

In a previous paper (Onsman & Paganin, 2006) we argued that the range of applicability of an analogy under certain circumstances can be usefully stretched beyond its assumed limit: a process we referred to as a Perturbative Analogy. In that instance, we demonstrated the use of a Perturbative Analogy to overcome writer’s blocks in postgraduate students studying either neuro-cognition or quantum science: two disciplinary fields where much of the accepted knowledge is necessarily grasped by means of analogy because little of the activity in either the subatomic world or the active brain manifests in classically predictable ways (Friston, 2009;
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Penrose, 1994). In short, because certain subatomic and mental processes are unlike any directly-apprehendable empirical processes, we can describe them neither analogically nor literally with any absolute degree of manifest or verifiable accuracy.

In this paper we argue that it takes a range of analogies that infer individual defining characteristics of a process to provide a workable conceptual understanding of it. Rather than indicating a developmental strategy, the range of analogies is not necessarily sequential, or cumulative. Instead we propose that the range of analogies is context specific, allowing a particular conceptual understanding that will be fundamentally utilitarian. Whilst at least for the present, the indefinable remains beyond us, the function of individual aspects of it are possible to grasp, given a delineation of context.

Unknownable-ness

The notion of the unknowable has assumed an accepted if controversial place in most domains of knowledge. In particular, late twentieth century schools of thought such as post-modernity are very much aligned with the concept of unknowability; the “incredulity towards meta-narratives” (Lyotard, 1984) of the post-modern annihilates the dominant meta-narrative implied by the concept of absolute truth – where “true” equates to “real”. Fundamentally, post-modernity assumes that a state of change is now constant and therefore any notion of progress is obsolete or irrelevant. As a result knowledge is necessarily context-bound, faceted and fragmentary: a given particular instance is grasped from a particular non-privileged perspective, with no particular perspective dubbed canonical.

In philosophy, Jean Paul Sartre for example, argues that all that is knowable at any given time is the sum of a “series of appearances”:

Modern thought has realized considerable progress by reducing the existent to the series of appearances which manifest it. Its aim was to overcome a certain number of dualisms which have embarrassed philosophy and to replace them by the monism of the phenomenon. Has the attempt been successful? In the first place we certainly thus get rid of that dualism which in the existent opposes interior to exterior. There is no longer an exterior for the existent if one means by that a superficial covering which hides from sight the true nature of the object. And the true nature in turn, if it is to be the secret reality of the thing, which one can have a presentiment of or which one can suppose but can never reach because it is the “interior” of the object – this nature no longer exists. (Sartre, 1956).

The psychoanalyst Sigmund Freud argues that reality is ultimately unknowable:
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*Reality will always remain “unknowable”. What scientific work elicits from our primary sense perceptions will consist in an insight into connections and interdependencies which are present in the external world, which can somehow or other be reliably reproduced or reflected in the internal world of our thoughts, and the knowledge of which will enable us to “understand” something in the external world, to foresee it and possibly alter it.* (Freud, 1949).

However, the physicist Stephen Hawking takes a more pragmatic line:

*I don’t demand that a theory correspond to reality because I don’t know what that is. Reality is not a quality you can test with litmus paper. All I’m concerned with is that the theory should predict the results of measurements.* (Hawking & Penrose, 1996).

The nature of knowing and knowledge has long been a topic of interest for philosophers, physicists and psychologists alike and we are by no means suggesting that the ideas quoted above are representative of the myriads of contestation and creativity within each discipline. Rather, we point to the evident: each discipline has much to offer the other. This is what we assume Gould meant by “a breadth of interest”.

Although the concept of absolute unknowable-ness is far more complex that is indicated here, we point to one specific aspect that relates to this particular paper. This example concerns the question of a physical model for material matter in the physical sciences. Both contemporary and antecedent physicists have given a multiplicity of models for matter: the idea of matter as an indivisible continuum, the notion of matter as being composed of indivisible building blocks known as atoms, Kelvin’s notion of atoms as vortex knots in the luminiferous ether (Kelvin, 1867), Thomson’s “plum pudding” model of the atom (Thomson, 1904), Rutherford’s solar-system-like classical model of the atom (Rutherford, 1911), Bohr’s solar-system-like quantum-mechanical model of the atom (Bohr, 1931a,b), the model of the atom based on probability clouds as predicted by the Schrödinger equation of non-relativistic quantum mechanics (Messiah, 1961a), and the model of the atom based on probability clouds as predicted by the Dirac equation of relativistic quantum mechanics (Messiah, 1961b). The last two models are routinely used by contemporary physicists, with some of the earlier models (such as the Rutherford model, and even the Bohr model) also continuing to be used in certain modern physics contexts (such as alpha particle scattering from thin gold foils (Messiah, 1961a), or Rydberg atoms (Hezel et al., 1992); we return to the latter example below). The salient point here is that we consider that none of the above models, whether or not they be in contemporary use by modern physicists, to be elevated beyond the status of “a” model to the privileged status of “the” model associated with what matter is “really” like at the microscopic level. Indeed, the correspondence principle of quantum mechanics (Messiah, 1961a) effectively dissolves such a question of seeking a “privileged” model, a point which we parenthetically remark to be rather directly aligned with the previously-mentioned post-modern “incredulity towards meta-narratives” (Lyotard, 1984). Rather, one has a series of mathematical models for the physical world, of various degrees of
applicability and accuracy, and varying degrees of utility in considering a particular physics problem. All of these models may be viewed as tentative hypotheses that have varying domains of validity and varying degrees of context-dependent utility and legitimacy; even the most general theory of those listed above (that based on the Dirac equation) may be superseded at any point in the future by a more general theory that adopts a fundamentally different model to that offered by the Dirac equation. The physicist builds models, rather than directly apprehending an un-knowable reality.

Disposable Analogies

The term “Disposable Analogy” has in the past been used solely in post-modern critical theory:

…the almost universal use of the “organic” metaphor during the early-Romantic period is really the intuitive recognition of the structure of a metaphysical argument. To invoke life, in this context is not merely to invoke a disposable analogy (the artist is more like a plant, less like a machine or a logician); it is to see that art is life at the human level – and not merely comparable with life – and that the forward striving of life, or of meaning creation, which is present in all human existence is present most purely and quintessentially in our creation and appreciation of art. (Falck, 1994; p80).

Whilst Falck’s implication is that all analogies are disposable because they are mere indications rather than actual referents, there is a somewhat serendipitous connection to our use of the term in that the purpose of life is seen as the creation of meaning. Whether or not that striving is quintessentially in the creation and appreciation of art seems to us to depend entirely upon what is, and importantly, what is not seen as art. Given that the quintessences are the essential truths that can be observed through the five senses, Falck’s summary of the dominant conception of life during the Romantic period suggests that art is the striving to understand, portray and expand those observations. In that sense, we suggest that Science is striving to achieve much the same end.

Our use of the term Disposable Analogy refers more to the limitations of vehicle analogies in the understanding of a specific element of the tenor analogy1. In point form we might describe the process thus:

- I want to teach you about A. You are unfamiliar with A, but you are very familiar with B. So I use the analogy “A is like B” as a teaching tool, to help you learn about A.

1 Whilst we acknowledge the on-going contestation of I. A. Richards’s terminology and conceptual approach to non-literal language (e.g. Douglass, 2000), the terms are still widely used. The tenor refers to the concept to be learnt, the vehicle to the analogous concept.
I’ve taught you about A. Now you know a lot about A. I want to help you learn even more about A. As a teaching tool, we discuss how A is *not* like B.

Eventually, the analogy “A is like B” is contextualised, and disposed of as the sole mechanism for understanding.

Both the *parallels* between A and B, and the *differences* between A and B, have teaching value.

As an example of the utility of such disposable analogies, many people first encounter the structure of an atom as being like a solar system, an analogy associated with Sir Ernest Rutherford (Rutherford, 1911) and Niels Bohr (Bohr, 1913a, 1913b). It is a useful image to guide the broad structural aspect of an atom: a central mass with orbiting satellites. The analogy retains a great deal of currency and for many people is the key referent for their visualisation of atoms. For example, the United States Department of Energy, which has subsumed the Atomic Energy Commission, still uses the image as part of its logo.

Having grasped that specific aspect of “atom-ness” conveyed by the solar system model of atoms of Rutherford or Bohr, to gain a more exact understanding requires the analogy to be abandoned because in most aspects an atom is not like a solar system at all. Having learnt that an atom is like a solar system it now become necessary to learn that an atom is not like a solar system, while retaining the understanding that in that one specific way an atom is like a solar system. However, the analogy is not entirely disposed of but rather assumes a place amongst a series of potentially useful analogies any of which may be called up again as required, depending on circumstance, context and purpose.

For example, the Bohr “solar system” model for a hydrogen atom may be replaced by a significantly more general theory based on the Schrödinger equation, in which the “orbiting electron” is now considered to be smeared out through space (Schrödinger, 1926; cf. Messiah, 1961a). This smearing of the electron into a “probability cloud” serves to break down the utility of the solar-system analogy. Having said this, certain solutions to the Schrödinger equation are known, which correspond to a very energetic level of electron excitation. In such “Rydberg atoms” (Hezel et al., 1992), which may be studied within the context of the Schrödinger theory, one regains the idea of an “orbiting electron” which was initially “discarded” in moving from the Bohr to the Schrödinger theory. Incidentally, this furnishes a nice instance of the demand that a new physical theory should reduced to the old, in the domain of validity of the latter, if the newer theory is indeed a super-set of the older theory; this latter requirement is often but not always met in contemporary theoretical physics.

Returning to the main thread of the argument, there are two possible ways to model the collection of potential analogies for a single target concept: as a hierarchy or as a network. Either serves to illuminate the process, depending upon the purpose to which it is put. These two possibilities are respectively treated in the following two sub-sections.

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2 See for example, [http://www.energy.gov/](http://www.energy.gov/) (Accessed 15/05/2009)).
Hierarchies of Analogies

Having disposed of the analogy “A is like B”, and thereby brought the learner to a given level of understanding, one may go to a deeper analogy: “A is like C”. Parallels, then differences, are made use of (in that order). The process may be continued as per the flow chart below.

The assumption here is that the process is developmental, a progression from simple to more complex understandings as well as from gross vehicle concepts to more sophisticated concepts. The consequent definition and re-definition of domains of knowledge in the direction of expertise has important connotations for how the educative environment can be most effectively structured for learning.

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<td>A is like C</td>
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<td>A is like D</td>
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<td>A is not like D</td>
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A critical aspect of the process is the necessity that analogous learning includes both comparison and contrast, which again raises the notion of disposability. What we emphasise is that rather than analogies becoming superfluous as new, more complex analogies allow for more expert understandings, each retains currency and a potential applicability.
There may be concern that as analogies are used to explain and learn aspects of a concept or process and then “untaught” as it were, the possibility emerges that contradictory understandings may arise. In fact, as mentioned above, accessing a number of diverse and at times apparently contradictory analogies for a single concept is quite common in physics: here one again has the idea of a network of physical theories, none of which pretends to describe an ultimately unknowable reality, but which instead constitute a set of facets, a multiplicity of perspectives (Berry, 1998). For example, there are five or six different contemporary ways to describe a light field; the theoretical perspective adopted by a physicist will be based on utilitarianism (Paganin, 2006). In simple terms, the physicist will choose the physical theory which is most useful for solving a particular problem at hand. For example, an optical physicist or an observational astronomer may model light as a ray; a quantum field theorist may model the light in a laser cavity using the machinery of quantum electrodynamics; and a light microscopist may model light as a classical electromagnetic wave. These choices are made on the basis of utility – for example, quantum electrodynamics would overcomplicate the problem of light focusing by a lens, from the perspective of an observational astronomer; similarly, the ray model is often inappropriate for modelling light in a laser cavity.

An analogy hierarchy may be thought of as intellectual scaffolding in which a series of progressively “deeper” models (together with their associated analogies) ascends towards the ultimately unknowable. As an example we may ask “What is an atom really like?”: a question for which we have as yet no complete answer. We do have a number of analogous understandings, ranging from the commonly-held such as that it is like a solar system, to the specific such as that it is like a fuzzy cloud. Whilst the latter is apparently more sophisticated than the former, neither is in fact completely wrong or completely right. Any such assumption is irrevocably disturbed by the fact that in some contexts an atom is like the Rutherford’s J.J. Thomson’s “plum pudding solar system” model (a classic example is furnished by alpha-particle scattering by a gold foil (Messiah, 1961a)). In fact it is far more likely that the potential to dissolve the question rests in Sartre-like access to the sum total of the analogies rather than in an increase of complexity in the individual comparisons. Nonetheless, increasingly more complex analogies will progress understanding of atoms. The progress depends to a large degree upon the meaningful interpretation of phenomena registered through the senses. Farkas (2008) explains it thus:

“The first step in meaningful interpretation is perceptual judgement, the ‘naïve’ or natural interpretation of a phenomenon by the brain. The interpretation of phenomena as meaningful signs depends on the observer’s knowledge about similar phenomena and earlier response strategies. This knowledge … is invoked by the observed phenomenon as input … . By interpreting the relation between the input and the memory information the actual meaning of the input is determined by the observer. (Farkas, 2008; p13).

It has been well established that the brain records external stimuli in static representations. These static representations are understood dynamically through interpretation, much in the same way.
that a series of static frames can be processed as a moving image (for an overview see Roediger & Blake, 1987). This is an interesting assumption because it implies that the brain simultaneously interprets the individual representations and processes the grouped representations dynamically as meaningful experience. For our purposes however, it supports our proposal that response strategies – because they are purposeful in practice – are likely to be dynamic. We may point to the understanding of history as a more complex analogy of the same process. Although events are most probably indiscriminately recorded as static and un-interpreted phenomena, history is an assumed and edited continuum. Whereas a movie can be stopped and examined frame by frame, history is more often conflated into dynamic interpretations that are representative as much as they are exemplary.

**Networks of Analogies**

For all intents and purposes, the notion of simpler and more complex analogies is itself a metaphor. Successfully processing more complex analogies is probably a more involved mental activity than successfully processing simple analogies. However, simplicity and complexity are idiosyncratic evaluations that are relative. What is a simple concept for an expert particle physicist is often an extremely difficult concept for the layperson. Conversely, the highly expert scientist often has no hesitation in affording equal status to the simplest of concepts if that is what will progress his or her understanding: the aim of the exercise is to get a workable grasp of the problem at hand rather than necessarily employing the most complex analogies.

In order to avoid the deep/surface metaphor implicit in the notion of the analogy hierarchy, it may be more profitable to reconstruct it as a non-hierarchical network of analogies as per the schematic below. Note that there are no arrows on the links between the nodes. This indicates firstly that they may be traversed in either direction and secondly that the direction of the link is variable. Given that the edges of cognitive domains of knowledge are most likely vaguely defined (if at all), it seems to us more likely that the linking process is similarly indirect. It is a defining aspect of adult cognition that knowledge is tested, monitored and verified through continual use.
Further, it has been generally accepted during the last decade that new information is adapted to fit into general domains but in specific fields of expert knowledge the domain is adapted to accommodate the new knowledge (Hoyer & Rybash, 1994). As is usual in most paradigmatic models of analogous cognition, we suggest that analogous reasoning is the manifestation of such elasticity within and between domains of expert knowledge (Hancock & Onsman, 2005).

From a pedagogical point of view, we propose that the meta-cognitive process of tracing a path, through a suitable analogy network, may be a useful teaching/learning/thinking tool. Given that part of learning to operate as a scientist (or any other occupation) requires the occasional by-passing of the notion of complexity, students may be guided to cognitively visit a given node more than once in the “journey” through the analogical network which is effected as their understanding develops. In summary, rather than disposing of a given analogy before moving to another node, one embraces the idea of a multiplicity of different viewpoints, and thereby actively seeks to increase the degree of connectivity of the multiple nodes in the analogical network. We shall return to this point later.

**Rings of Analogies**

In practice, it is improbable that all possible “like/not like” alternatives will be accessed to create meaning. It seems more likely that enough nodes will be joined to make satisfactory meaning appropriate to the context. For example it may take no more than three nodes, together with their connecting links, to give the analogical ring illustrated below.

![Diagram of an analogical ring](image)

The point we make is that once satisfactory meaning is made there is no necessity to increase either the number of nodes or the degree of connectivity in the ring. Moreover, one may move around the analogical ring such that a given node is “visited” more than once, in a cyclical process whereby a subsequent “visit” to a given node will view the said node from a different
and deeper perspective than was adopted during an antecedent visit to the same node. Stated differently, a given analogy may be deepened as a consequence of one’s experience with alternative analogies; one may “leave” a given analogy “A is like B” to pursue a “higher” analogy “A is like C” and a “still higher” analogy “A is like D”, only to return to the original analogy “A is like B” from a “higher” perspective still.

A classic example of this process of cyclical traversal of analogical rings, again taken from theoretical physics and elucidated in more detail below, concerns the nature of light. This example, together with its more abstract articulation above, demonstrates that a ring of analogies implies that there is no notion of obsolescence: that an analogy used in the first instance to make meaning retains its agency. Further, there may be instances when the initial analogy is enriched by the subsequently used analogies. As an example, we cite our understanding of “light”. In (point form) summary, light is like:

- a particle (Pythagoras, Newton view of light as a corpuscule);
- a ray (view of light as described in the “Optics” of Euclid);
- a wave (classical wave theory light due to Huygens, Hooke, Fresnel);
- a wave (more sophisticated classical theory of light, due to Maxwell);
- a ray (Poynting vector field associated with Maxwell equations);
- a particle (Einstein view of light as a particle, in context of quantum theory of light);
- a ray (as derived from classical short-wavelength asymptotics);
- a wave (wave equation for vector potential, as a prelude to electromagnetic quantisation);
- a particle (localised quanta of excitation for quantized electromagnetic field).

The analogy “light is like a particle” is visited at one level of sophistication, then revisited twice at progressively higher levels of sophistication, in the course of traversing the analogical ring. In diagrammatic terms, the ring looks like this:

![Diagram of the analogical ring for light](image-url)
Light is like and not like a wave; like and not like a particle; and like and not like a ray. Undoubtedly the contemporary analogous understanding of light like a particle is more complex and probably more complete in its explanatory capacity than that of Euclid but on the other hand the contemporary understanding lends respect to the earlier one. We stress that the operating principle is one of different but equally valuable functionality. To illustrate the point, Roychoudri and Roy (2003) asked six internationally renowned experts in optical physics to define a photon: fundamentally, to explain light. Each came up with a different definition. None of the scientists would necessarily claim that their definition was better than anyone else’s, but rather that each approached the question from a different (albeit related) point of view.

There is an obvious connection between networked analogies and Schema theory. Gerald Edelman (Edelman, 2007; Edelman, 2003; Seth, Izhikevich, Reeke, Edelman, 2006) has long argued that knowing is a neurological process defined through adaptation and natural selection. According to theories of expertise, having more than one analogy-dependent understanding of a concept suggests that a new cognitive domain has been created; neurological pathways have been established that flow from and to a particular node. This view is described by Talosa et al. (2008) as functionalist since it involves the combination of spatially diverse elements. It should be noted that a functionalist view of neuro-anatomical behaviour is not seen as exclusive from a structuralist view but rather that they are complementary. In any pedagogic context, function without structure is meaningless and structure without function is purposeless.

**Conclusion**

To once again roam more broadly, we suggest that returning to a earlier analogy after having accessed others is like returning to a favourite poem or piece of music: both comfortingly familiar and excitingly new. As the poet T.S. Eliot (1971) eloquently put it:

*We shall not cease from exploration  
And the end of all our exploring  
Will be to arrive where we started  
And know the place for the first time.*  
(Four Quartets, Number 4, Little Gidding: V, 239–242).

We see networks of analogies as bridges not only between disparate fields of knowledge but also between disparate epistemologies and ontologies. For example, we suspect that a plethora of additional aspects for our understanding of light lies within indigenous knowledge systems. It would be an illuminating exercise to ask physicists to reconcile the Apache understanding of the origin of light with their own:

*In the beginning nothing existed – no earth, no sky, no sun, no moon, only darkness was everywhere. Suddenly from the darkness emerged a thin disc, one side yellow and the other side white, appearing suspended in midair. Within the disc sat a small bearded man, Creator, the One Who Lives Above. As if waking from a long nap, he rubbed his*
eyes and face with both hands. When he looked into the endless darkness, light appeared above. He looked down and it became a sea of light. To the east, he created yellow streaks of dawn. To the west, tints of many colors appeared everywhere. There were also clouds of different colors. (www.dreamscape.com/morgana/miranda.htm, accessed 15/05/2006).

What we are suggesting here is that one of the constraints of acquiring expertise is a distancing of non-linked domains of knowledge from the area of expertise. The notion of variation in the strength of or the ease of access to the links between nodes on a network of analogies is as yet a largely unexplored area of study. In fact, one of the areas where a network of analogies might be profitably used is in the area of considering how analogies work. To give some direction to future studies, we can point out that amongst other things an analogy is like (and not like) a ladder, a ring, a scaffold, a tree, a rhizome (cf. Deleuze & Guattari, 1972; Deleuze & Guattari, 1980), an intranet, a chain, a comparison, and a contrast. Further consideration needs to be given to what these analogous representations of analogy exactly refer to. This notion may be summarised as contextually bound functionalism: that the effectiveness of an analogy as a conceptual bridge is determined to at least some degree by the context in which it is placed. As educators then, we must ask how explicit can we become in terms of understanding how the attempt to grasp unknowable concepts elevates analogy to a primary role in both cognition and expertise?

References


