CROSSTALK, MUTATION, CHAOS:

THE USE OF SCIENTIFIC VISUALIZATIONS AS ANALOGIES FOR TEXTUAL RECEPTION; BRIDGE-BUILDING BETWEEN THE SCIENCES AND THE HUMANITIES VIA VISUAL ANALOGY

A RESEARCH DOCUMENT

Dr. Mario Petrucci

Abstract

"Everything one invents is true" *Gustave Flaubert*

With the student body increasingly attuned to visual input, and tertiary education involved in modular degree-building, visual analogy might contribute a pertinent means to investigate new learning interfaces between disparate subject areas, helping to galvanise fresh modes of creative-critical teaching across the disciplines. Indeed, David Bohm's hypothesis of an ultimately-unified universe (interpreted here, for conceptual space, via a 3D Venn diagram) might even suggest that *any* visual analogy – by its very existence – opens a potential window on the infinite 'whole' of Intertextual discourse. Whether or not this proves to be the case, there is a growing sense in some quarters of education that conventional text-based methods and models are, at best, partial. The type of educational analogy emphasised in this paper – termed a 'Visualization' – consists of a visual abstraction derived from observable phenomena. A number of Visualizations arising from technology and science are presented, including a spectrum analogy for Intertextuality, subsequently developed into a filter analogy casting a particular light on translation. Further examples include reception processes framed in terms of genetics, crosstalk and chaos theory. These attractive scientific forms, offered in a spirit of serious play, represent a work in progress, requiring consolidation; but they serve to prime the more ambitious enterprise of exploring the application of this approach across many fields of study. Having already been used to ignite participatory discussions among literary studies students, this work has as its eventual goal the provision of an array of Visualizations operating across the sciences and humanities.

I. PREAMBLE

An early typo in this paper's title was: 'Crosstalk, *Mutilation*, Chaos', a slip of the keyboard not altogether unwelcome. My intention was indeed to cut myself off (Latin: *mutilare*) from rigid pedagogy and watertight methodology, to embrace creative modes more in resonance with the pick-'n'-mix way in which much of our learning actually occurs. I was seeking thesis *and* praxis, somehow combined; but more akin, conceptually, to a raft of overlapping bubbles or the rhizomes of Deleuze & Guattari [1988] than to linear models such as (say) the formal stages of Piaget (useful as these often are). And yet, I have no desire to belittle the better conventions in teaching; perhaps mutation is, after all, a preferable metaphor for what is going on here, which is very much a work in progress awaiting confirmation and refinement by its commentators and users. In keeping with the paper's wider goals, I also felt it crucial to present ideas as far as possible through visual modes.

II. A TRIPOD OPENING

Essentially, my approach rests on: (**1**) an interpretation of Kant's analysis of perception and cognition (at the start of 'Transcendental Doctrine of Elements'); (**2**) the writings of David Bohm; (**3**) an insistence upon analogies as opposed to models.

Leg 1: VISUALIZATION and VISUALIZABILITY

The fuse for deepening and consolidating my early attempts to link literary studies and the sciences through visual analogy was provided by Kant's [1934, p.41] distinction between *sensation* and *intuition*, concepts which have since been developed as the technical terms 'Visualizability' and 'Visualization' [Miller 1996, p.45]. In fact, Miller was invaluable in testing my terminology, since I had already coined 'Visualization' for myself and was thinking through my own interpretation of Kant's distinction: *sensation* (or *Anschaulichkeit*) as the Visualizability presenting itself as concrete physical behaviour; and *intuition* (or *Anschauung*) as the abstract Visualization deduced by the observer. The details of Kant's (or any subsequent) use of these expressions need not concern us here

[1], particularly as my wording and sense may not correspond with what is given elsewhere in the literature. For the specific purposes of this paper, I define the relevant terms (below) quite generally.

Visualization   A visual abstraction, derived from (and somehow representing) a fundamental pattern of behaviour informing observed phenomena. A Visualization is *conceived*.

Visualizability   Some set of characteristics exhibited by the given phenomena which enables them to be interpreted as a Visualization. Visualizability is manifest; it is *perceived*.

A useful illustration here is the familiar physics experiment, where iron filings are sprinkled on a piece of card lying on a bar magnet. Tapping the card generates 2D patterns in the filings which, though never quite identical, are distinct and recognisable, arising from the Visualizability of the magnetic field as expressed in that type of set-up. Varying the experiment enables a systematic and intuitive observer to map out the Visualizability, and eventually to discern (as stated in the definitions above) the underpinning "pattern of behaviour informing" it, thereby extracting a 3D representation of the magnetic field in terms of 'lines of force'. This generalised, abstract representation is the Visualization. My relatively straightforward example should not lead, however, to the misconception that a Visualization is just a technical drawing of observed results, an imitational diagram that merely simplifies or 'cleans up' the perceived Visualizability. Visualizations reach deeper than that: realized cognitively as an abstract form, they preserve (however obviously) some aspect of the organising forces involved. Often, this abstraction is quite different, visually, from its originating phenomena: the emission spectrum for hydrogen, for instance, observed as a series of coloured parallel lines on a dark background (= the Visualizability), may be interpreted through the much-used Visualization of a quantized solar system, where an electron orbits the nucleus at definite energy levels.

In a previous incarnation as a physicist, I worked with Visualizations all the time; more recently, I have begun to ask whether there are Visualizabilities operating within (or between) texts which might correspond, however weakly, to Visualizations deployed in scientific circles. Here, I extend the 'phenomena' of my definitions beyond the merely physical processes of science, to include systems of signification such as text, cultural artefacts and conceptual operations. Might it be possible then, in this reformulation, to develop specific scientific Visualizations that operate as analogies for certain aspects of critical-creative discourse in literary studies, thus forging new links between the two fields? My initial impetus of curiosity rapidly evolved into a constructive challenge against those regions of literary investigation conventionally, and overwhelmingly, rooted in text [2].

Leg 2: IMPLICATE ORDER, CONCEPTUAL SPACE: the VENN VISUALIZATION

My reasons for pursuing this research are partly intuitive, mainly empirical (invigorated students, elated colleagues) and, to a degree, theoretical. In this last respect, Bohm [1983, 1996, 1998, 2000] provides some of the cardinal concepts, excavating issues at the very core of science, perception and order. Put simply, and in deep paraphrase, Bohm's *Explicate Order* is what we observe when the universe delivers itself to our senses or instruments according to clear (i.e. stable, recurrent) patterns of behaviour – as with the iron filings above. It is akin to Kant's *sensation*. An *Implicate Order*, however, denotes a hidden layer of organisation which underlies the *Explicate Order* and from which the Explicate behaviours unfold. One might tentatively suggest, then, that Visualizability is related to *Explicate Order*, while Visualizations reflect the deeper organising forces of *Implicate Order* (these, I stress, are provisional thoughts generated within and for this particular study). For Bohm, *Implicate Orders* continue without limit, implicating the whole in every Explicated part, so that even (what may seem to us) unrelated, random or chance phenomena will 'make sense' at some buried level [Bohm & Peat 2000, p.127]. The totality at the deepest levels of *Implicate Order* is termed the *holomovement*, which is "unknown and undescribable" [*ibid*., p.180].

Hólos (Greek) = *entire* or *whole* (as in 'hologram'). Bohm's term is therefore precisely constructed, indicating that apparently discrete entities or separate phenomena are simply the local expressions of an essentially fluxile, ultimate unity. The self-contained, autonomous entities of science are thus approximations: seen in a sufficiently broad context, they constitute particular unfoldings of the undivided *holomovement*, "rather than disjoint and separately existent things in interaction" [Bohm 1983, p.157]. Bohm applied his ideas to language, literature, music and art – drawing all life and, indeed, our very consciousness into the *holomovement* [3]. If there is anything to his conjecture, then it is important to continue the cross-exploration of subject areas traditionally kept well apart, utilising all the means at our disposal. There would seem no patent reason not to include visual analogy, at

least initially, among the candidate tools, particularly as analogy is a key method by which likenesses are revealed. In any case, however hypothetical and experimental the enterprise may seem, I find it irresistible that the formulation of cross-disciplinary analogies may be nibbling a little way into the universe's underlying structures.

If Bohm's ideas (or my application/ interpretation of them) were to prove erroneous, my approach would still not be altogether sunk. After all, in our everyday operations, "we almost always express ourselves by conceptualizing one domain of entities in terms of another" (Miller [1996, p.219], invoking the work of Lakoff & Johnson [1980]), suggesting that analogy plays a primary role in language and thought. Indeed, for some theorists, analogy is fundamental to the whole of human cognition and perception [Hofstadter, 2001; Chalmers et al., 1991]. What is more, given that linguistic and visual forms overlap on some level, cognitively, then it is plausible to suggest that the ability of language to connect widely different aspects of experience and knowledge may be reflected by a similar capability among visual forms (as evidenced, to some extent, by existing visual analogies). In short, using visual analogy to engage the possible concurrences between such disparate concerns as (say) electronics and translation may not be as absurd as it first appears.

One should note that 'non-Bohmian' science, too, driven by the desire to rectify its theoretical and experimental anomalies, seeks to expand its understanding through an ongoing process of consolidation, extension and assimilation, revealing deeper cognitive layers that not only deliver fresh insights and raise questions of greater profundity but also (importantly in this context) enable hitherto unrelated zones of scientific observation to be yoked together. In physics, for example, magnetism and electricity were spliced (as electromagnetism) through Maxwell's Equations, themselves then shown to be consistent with Einstein's theory of Special Relativity. The attempt to unite all the forces of nature under a single banner continues, ultimately leading (many hope) to Grand Unification Theory and that Holy Grail: a 'Theory of Everything'. By analogy, then, and given an equivalent desire across many fields of inquiry to overcome artificial delineations and the various anomalies these create, the activity outlined in this paper might warrant some attention. Returning to Bohm [1998, p.26]: "Certain kinds of things can be achieved by techniques and formulae, but originality and creativity are not among these. The act of seeing this deeply (and not merely verbally or intellectually) is also the act in which originality and creativity can be born."

Figure 1a attempts to represent aspects of the above thinking, via a Visualization of conceptual space drawn from Venn diagrams. Extended from their usual two dimensions into 3D, the Venn circles, here, become Venn spheres (or 'bubbles'). Each bubble is a portion of conceptual/ cognitive space, standing (in our case) for some means of understanding text: an analytical technique, say, or a particular theory or model; or, for that matter, a Visualization concerning text. Bubbles have correspondences with other bubbles, which is where (and why) they overlap. Since each bubble overlaps with many others, the analogy only really works in n-dimensional space, i.e. within the 'totality' of conceptual space. Such a space, however, is not easy to Visualize (i.e. to represent as a Visualization); so the 3D perspective will have to do. **Figure 1b** extends the analogy to suggest that logical/ conceptual space only represents part of the picture. Other modes of textual reception [4] can be Visualized, creating 'bubble-rafts' which also overlap in a Venn manner (again, in n-dimensional space). These complex overlapping spaces provide a possible Visualization (albeit rendered in a primitive, approximate way) for the complete human experience (the 'sum', Σ) of a text.

Within this Venn analogy, the limitation of a critical commentary relying upon a few separated-out bubbles of conceptual space is not difficult to spot. Nor is it a huge step to a striking hypothesis going far beyond any sense of the analogy as merely representing how, in practice, certain connections can be found between different modes of textual analysis or assessment: if consciousness itself – along with its concept-making – arises from Bohm's *holomovement* (which is, admittedly, far from proved, and may even remain unprovable), then it follows that every conceivable bubble in my analogy (i.e. *any* theory, model or Visualization we can construct or imagine) must somehow, at the deepest levels of *Implicate Order*, 'overlap' with all the others *by mere virtue of its conceivability* [5]. It is then a matter of what forms those overlaps take and how, if at all, they can be made clear or describable. One supposes that most would occur at too profound a level to be easily grasped or explored; but that may not be true of them all. This, in a sense, restates the teacher's instinct that ideas produced by students in moments of intuition, however wild in content and form, can usually be turned to some good – and here, at the very least, is a mechanism (albeit a hypothetical one) by which Visualizations derived from one field of study may have resonances (or perhaps even applications) in another.

One might now ask whether an analogy is best seen (in the Venn Visualization) as its own discrete bubble overlapping strongly (with the source-target bubbles it happens to interrelate), or as part of the content *within that overlap itself*; perhaps analogy-making is a key aspect, generally, of the very *quality* of overlapping – which returns us to the potential value of analogy (in general) and visual analogy (in particular) in future cross-disciplinary work. Whatever its success in that respect, however, analogy-making is not a facile skill. Even in promising cases, some trial-and-error, tutorial guidance and intuitive sifting is usually needed, to clarify and optimise emerging correspondences. But let this leg end with a kick of satisfaction: that a Visualization drawn from mathematics (in Figures 1a/ 1b) forms part of my proposal to link science and literary studies through Visualizations!

<div align="center">

Leg 3: ANALOGIES versus MODELS

</div>

My final, stabilising leg differentiates models from analogies. 'Analogy' stems from the Greek *análogos*, meaning *conformable* or *proportionate*; 'model' is based on the Latin *modulus*, denoting *measure*. Models are characterised, tested and assessed by their ability to (measurably) repeat and predict; analogies are generally more fluid, flexible and interpretable, operating through suggestion or parallels. Analogy, I suggest, rides much closer to simile and metaphor than to theoretical modelling [6] (this endnote includes definitions of relevant terms). Scientists – in spite of their reliance on scientific protocol and mathematics as major means of expression, prediction and verification – often resort to simile, metaphor and analogy (rather than models) in the explication and popularisation of their ideas, as well as in the perception of phenomena. Such use can be described as "a process of transferred pattern recognition" [Wall & Tudor Jones 2006, p.467]. This – our innate, developing ability to recognise transferable patterns – is far from exhausted. I believe analogies can be exploited more extensively in the provision of broad and accessible gateways into and between a variety of subjects. After all, scientists themselves have long recognised the benefits, in teaching contexts, of a good analogy over a precise model [7]. A model is subject to the concepts, conventions, procedures and terminology of its discipline, and so requires from the novice an (often) extended process of cognitive acquisition along distinct pathways; a good analogy, though, makes up for what it may lack in rigour by having one foot in something more familiar to the student than the specialist field it relates to, thus generating important initial inroads and insights for fledglings of that new or difficult terrain.

My chief reason, however, for keeping these investigations model-free (at least at this stage of the project) is that attempting to formulate thoroughgoing models linking the sciences with textual analysis would probably lead to something complex, technical, arcane, programmatic and (particularly for non-specialists) dull. I prefer to develop attractive, accessible visual analogies that might prove exhilarating, fruitful and liberating. Progress has already been made: some pilot Visualizations, drawn from the scientific domain, are offered below to act as analogies for certain aspects of textual reception. Each therefore has (to some extent) the inbuilt character both of an analogy *and* of a scientific Visualization. From here onwards, it should be noted that the simple term 'Visualization' may well refer to a Visualization of this analogic type. Moreover, although it has been helpful in these opening passages to define and understand Visualizability, discussion will now tend to focus on Visualizations, particularly for practical application.

III.   INTRA-TEXTUALITY and the TEXTUAL CONTINUUM

My first Visualization from physics is based on a spectrum, the best-known example of which is the electromagnetic spectrum. This has (short wavelength) x-rays and gamma rays at one end and (long wavelength) radio waves at the other, with the rainbow of visible colours arrayed between. **Figure 2** relates this straightforwardly linear visual structure to Intertextuality (a term I deploy, here, in a most general way, to accommodate the whole variety of possible characteristics of texts as well as the relationships between/ within texts and their language bases [8]). The resulting 'Textual Continuum' is available to Intertextuality in its various degrees, gradations and types. Along this line, relevant features of the text(s) are identified, related to other texts or characterised according to familiar Intertextual modes. For instance, blatant plagiarism, direct quotation and (at the very limit, perhaps) verbatim reproduction occupy the most Explicit [Pope, 2002] extreme. My *Intra → Implicit → Explicit* progression is in no way definitive, however, and the figure's detailed annotation is mutable, a particular example of what might be envisaged. The way a given text is placed on (or profiled/ mapped along) the line will of course depend on how the continuum is interpreted, what it is in the text that interests us, and the stage of composition/ reproduction/ reception at which such issues are addressed. One student might view the figure as little more than a convenient axis whose 'wavelengths' loosely signify specific

Intertextual insights; another user might decide that peaks in the spectrum should correspond to particular, characterising modes of Intertextuality and their cultural reception, as though we were seeking to register a series of 'resonances' between the given text and literature/ culture at large.

I find it best if students, having grasped the basics of Figure 2, can (as far as possible) run with it themselves, allowing the Visualization to operate *creatively* (rather than prescriptively) as a hub for discussion involving the text(s) at hand. But, at some point, guidance is usually needed. Whenever drawing an analogy, one does well to ask such questions as "How strong is this analogy? Where does it break down?" The value of analogies lies as much in probing their shortcomings as in the insights they afford. Where those deficiencies are less conspicuous, greater cautionary effort may be required. One must also be wary, having successfully applied a scientific analogy to (say) a literary-critical situation, that students do not thereby confer upon that target some vague notion of scientific truth. It is all too easy for an actual, or assumed, conclusiveness concerning the source (here, the electromagnetic spectrum) to be transferred across, by mere association, to the literary subject (Intertextuality).

This case also serves to illustrate my reasons for insisting on the use of Visualizations as *analogies* rather than models. Even non-scientists will quickly realise that particular wavelengths along the continuum cannot be made to correspond in any rigorous, repeatable or complete way to the various attributes or effects of a text [9]. The deficiencies of the spectrum as a model (or even as *close* analogy) are therefore immediately felt. We can either take this as crushing evidence of the pointlessness of the exercise, or turn that very insufficiency to advantage, using it to investigate how and why we might dissect a text for distinguishable qualities, or as an incentive to test and deepen the Visualizing process itself. This requires an open and inventive responsiveness that is often its own reward. It can also yield fascinating results. Indeed, my particular version of Intra-textuality emerged, and was so labelled, because (to begin with) the spectrum needed *something* at its non-Explicit end, but also (later) because many students who rapidly got to grips with Explicit Intertextuality were less sure about what was going on at the Implicit limit. This uncovered an exciting area of discourse, prompting me to offer a means of approaching and negotiating (through gradations or 'fine structure') those regions of Intertextuality they were finding less obvious [10]. What is sought here – at least initially – is an illuminating variety of access and interpretation, rather than theoretical rigour or modelling capability at all costs. Too rigid an adherence to the details of the science would, I feel, have held this process back. In any case, scientific stringency is usually misplaced among the plural purposes to which such a Visualization might be put. Figure 2 was never intended to function, within literary studies, as some mimetic equivalent to the electromagnetic spectrum. It opens up productive questions more than it closes in on any final answer. In this kind of work, a Visualization and its target (for analogy) are best seen as siblings, not clones. (I shall say more about the limitations, and possibilities, of visual analogy in Section VIII.)

Further discussion on the spectral analogy is available elsewhere [Petrucci 2001a, 2001b]. In spite of its dualistic assumptions and its speculative, provisional nature, this analogy has helped to kick-start seminar debates on Intertextuality that have incorporated a variety of theories and approach, from Barthes [1981] to Pope [1995]. Not only has it raised issues around how one maps out Intertextuality in the first place, it has also focussed attention on what exactly is meant by any given (or mooted) Intertextual quality [11]. It has even been used – albeit at full stretch – to broach the difficult subject of authorship and originality, with (for example) the Explicit extreme stressing text as 'derived object' and the Intra-textual regime suggesting a unique, willed 'writing-subject'. Tutors may substitute preferred or alternative interpretations here; but, whatever the chosen slant, it does students no harm to visit, from this freshly analogic angle, the Intra-textual dark matter of our linguistic universe.

IV. CROSSTALK, MUTATION, CHAOS

The following figures further illustrate my early attempts to establish analogies that qualify, to some degree, as Visualizations across disciplines: that is, they store, visually, some recognisable pattern of characteristics, some parallel set of relationships, however basic, which illuminates not only the sourced (scientific) situation but also the targeted aspect of (here) textual reception. The examples presented certainly function as visual analogies, and therefore represent possible overlaps between relevant bubbles in conceptual space, linking the two fields; the extent to which they operate, genuinely, as scientific Visualizations may be rather less clear (see Section VI).

Figure 3 offers an analogy for mistranslation in terms of crosstalk, where signals from one circuit bleed across to another. The nuances of electronic circuitry are unfamiliar to most of my students, so

I discuss this via the scenario of crossed lines in phone calls. Taking each line, then, as a given language system, we might suppose that most signals (i.e. linguistic meanings) can be successfully 'translated' between two phone circuits because those circuits have roughly similar properties (i.e. the semantic processes underlying each language are not too unalike). However, some distortion, fading in and out, hiss, buzz, etc. often occurs, since the original signal may be only imperfectly (and noisily) picked up (= the processes of translation), while the new line may not have identical characteristics to the first (= different rules of syntax, etc.). Also, the signal is shunted across to an addressee who may not immediately grasp the original call's context (= different culture, etc.). Although the second medium does allow most of the original information through, skews and misunderstandings thus come about (e.g. strange idiom, wrongly connoted phrases, misfiring puns, an unintentional insult or joke).

Figure 4 presents evolution/ DNA as a possible analogy for the changing reception of a given text (or author's canon) across time. This particular analogy leans towards an essentialist view, insofar that it suggests that certain textual qualities and meanings are 'pickled' through reproducible cultural-linguistic codes, passed on more or less intact to subsequent generations of reader. Examples of relatively stable code might include the use of a traditional form, some undisputed fact or unambiguous biographical reference, or a distinct style. As with DNA, though, the particular codes associated with a text do not determine exactly how that textual creature will look or perform (within a particular brain or culture), thus opening up that old debate: nature vs. nurture. The analogy also recognises how textual codes can be intimately responsive to the complex, shifting environment of literary ideas and cultural signs. A type of Darwinism is implied here, with certain variations of code surviving because they are 'fit' for the altered environment (e.g. they align with new thinking). These changes in meaning can be adaptive (i.e. slight and slow, as in much of natural selection), as when an author's style gradually accrues esteem across generations; or they can be rapid and substantial (a sudden mutation), e.g. if a discovered cache of letters forces deep and precipitous re-evaluation of a famous biography. Naturally, the analogy has its flaws. Texts do not really behave – or propagate themselves, generation to generation – as do animals or DNA (though Dawkins' [1976] self-replicating units of culture, *memes*, may bring some validity to the overall notion). Nor do I use the terms adaptation/ mutation, quite, as technically defined in biology (my sense of mutation here is much closer to the populist idea of a severe alteration, or a mutant strain, as precipitated, say, by radiation). One might also challenge the very notion of codes being stored *in* the text, invoking instead reader-centred theories where the receiver (not the author, nor even the text itself) is the primary creator of the text's meaning. A fresh analogy, there, might be that of a textual quarry the reader excavates, seeking and constructing her own meanings from the raw materials of words and associations. This shows how analogies, once their inadequacies are acknowledged and incorporated, can be propped against one another to develop an evocative, extended mode of entry into a subject.

In **Figure 5**, chaos physics (often associated with weather systems) provides another engaging analogy for textual reception. Does a poem, say, arrive in the reader like a weather front of meaning, intricately modulated by all manner of inputs and accidents, with the complex 'environment' corresponding to the reader's personality and socio-cultural context, her experiences of other poems and related texts, indeed all her involvements with Intertext and context [12]? To coin a phrase: "Is poetry like the weather?" As with forecasts and outlooks, we can never quite predict the local detail of a particular text's reception within an individual reader; and yet, broad patterns may well emerge among readers in general, at least in the short term (it was fairly apparent, for instance, that the final instalment of Harry Potter would raise a storm of attention). It is interesting to note that the chaos analogy poses similar questions, essentially, to Jakobson's well-known model for communication [13], but there are contexts in which it may do so (*pace* Jakobson) more appealingly as a means to incite creative, open-ended discussion. Every student enters a seminar room with lived experience of weather and its forecasting; they may not be so nearly aware of possessing a 'code'.

V. ADVANCED / HYBRID ANALOGIES

None of the above analogies is presented as, in itself, a source of ground-breaking insight. If any of them seem a little obvious or simplistic, please bear in mind they are designed to be largely self-explanatory – which is, after all, a substantial part of their point. That said, they can be developed in far more depth, quickly becoming quite sophisticated. The continuum analogy, for example, may be expanded into a range of spectra, each representing a different aspect of the text's reception, thus generating a *Fan of Reception* (**Figure 6**). Here, the first 'fold' of the Fan is just Figure 2 itself, perhaps simplified, or focusing on key features of the *Explicit → Intra* progression. Subsequent folds

of the Fan highlight other traits of chosen interest. Even if a little too elaborate for some, the Fan should make it *visually* clear to most students that the apprehension of a given text is a complex process triggering many resonant functions between language and receiver. As an effective visual tool for introducing that idea, it can be used to initiate discussion on the possible nature and type of the spectra. Here, it is crucial to note the annotation stressing how the various functions are not isolated: they interact and overlap. This would seem to contradict the way in which the spectra are separated out within the figure; but this shortcoming can itself provide an opportunity for further debate. It reminds us that the Fan is not to be taken too literally, that there are shortfalls in every analogy – set, at least in part, by the skill of its designer (and the graphics software!). It also invites the observation that, in an attempt to handle material with clarity, literary criticism, too, can resort to a separation of thought, breaking texts down according to relevant characteristics or treating them within systematic (though, admittedly, often overlapping or hybrid) subject or category modes of analysis. From there, one can then consider what forms the links and resonances between the Fan's functions might actually take, what their relative strengths may be, and even how these overlaps could be better represented visually. A final thought: some of the annotations (Golden Age, Pre-Lingual, etc.) may not be clear to readers. These have no *special* significance here and need not be decoded; they merely show how one particular discussion developed. In this case, Aesthetic Fascism was a way of labelling the attempt by a pressure group (or regime) to define society's authoritative works, while Nescience was (hypothetically) a total ignorance of the canon; 'Intra-?' marked a query regarding the validity of Intra-textuality as a cogent concept; and so on. Naturally, participants should deploy their own detail – and, in any case, interpret the Fan itself – in ways they understand.

Figure 7 presents a second example of how the basic spectrum idea may be developed. It approaches the issue of what is lost (or preserved) in translation, through a filter analogy. Real filters (e.g. optical filters) allow certain portions of the input through (for light, the transmitted colours) whilst suppressing the rest (the absorbed colours). Figure 7b Visualizes the processes of translation in a similar way, as a kind of *frequency response spectrum* [14]: i.e. as a series of annotated peaks and troughs which (respectively) enhance or inhibit various characteristics of the input text (the source text spectrum in Figure 7a). Set up loosely for a 'free' (or 'Translator Response') approach, the merely illustrative form of the curve presented in Figure 7b is easily embellished. Trough 1 could indicate, for instance, the translator's disregard for alliteration (which happens to be prominent in the source text). Other troughs might stand for, say, areas of lexical ignorance, or qualities in the original the translator deems untranslatable. The crests, on the other hand, represent specific strengths, sensitivities or tendencies in the translator, including obvious aptitudes, interests and intentions. The asterisked peaks, for example, could identify particular habits of textual rendering, such as elements of stylistic bias in the translator's own writing style. Meanwhile, Peak 2 might indicate an attempt to convey, precisely, some perceived flavour in the source, with Peak 3 a decision to use, come what may, footnoted equivalents of proper nouns (e.g. Coventry for Dresden). The sense in which these constitute genuine 'peaks' – or some type of *amplification* – would, of course, be open to debate. It may become clear, too, that a simple light-filter analogy (where colours in the source merely do or do not get through) struggles with representing how a translator might *improve* or *add* something. Without getting too technical, one attempt to upgrade the analogy might involve a complex circuit or sound system that is able to sharpen up a signal or reduce noise, but which sometimes also adds blips to the output (though any fresh analogy should itself be subjected to due evaluation).

In a manner of speaking, then, the filter traces the 'shape' of the translator's likely treatment of the source text. Different types of translation (literal, accurate, free, etc.) can now be discussed by suggesting what the broad characteristics of each filter might be. For instance, in poetry, a literal translation might first be thought to entail a fairly flat, or neutral, set of transmission characteristics, where words simply pass through the filter without obstruction or translator bias. There will, however, be at least some *unintentional* troughs, because a word-for-word approach always leads to losses of certain textual attributes such as rhythm, rhyme, cadence and irony. It is important, though, not to focus *solely* on Figure 7b. With real optical filters, a strong feature in the input can sometimes partly survive what the filter tries to do with it – so it is with translation. Thus, a quality only weakly present in the original (a trough in Figure 7a) is unlikely to be picked up by a translator, while a prominent aspect (a large peak in Figure 7a) will probably not be missed, ignored or wilfully excluded (unless the filter of Figure 7b happens to have a strong trough at exactly that point). It should also be noted that Figure 7a displays just one way of mapping the source text along a continuum: in this case, via Intertextuality (interpreted in any way you wish). The annotation indicates that such mappings

can be done according to other types of concern, each treated separately. This leads to a more sophisticated approach entailing a fan of possible inputs, each having its own specialised filter.

Given that the interaction between the two spectra is the 'output' of this analogy (i.e. the source text translated into the target language), the process is easily enacted by placing a transparency of Figure 7b on top of Figure 7a (to the correct scale). This works wonderfully in teaching, bringing out the idea of the analogy crisply (whilst imitating the actual use of a filter), and providing a powerful, immediate visual grasp of the interplay between translator and source text. Again, as with Figure 2, the detail of the curves can be formulated quite differently from what is shown, and the specific nature and location of the proposed peaks and troughs is not to be agonised over. These curves are not reproducible fingerprints like the absorption spectra of gases or the emission spectra of stars; nor should the common perception of filters as purely mechanistic lead to any general conclusion that translation is merely a mechanical procedure (though computerised translations may indeed qualify). The deeper function of these analogies is to provide sites for initial understanding and study rather than any theoretical or experimental closure; once they have served their purpose, move on.
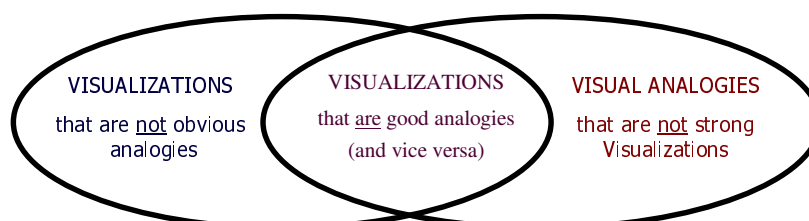
My final example (**Figure 8**) has more to do with study skills than literary studies, but I include it here for its aesthetic power and downright usefulness. This chart provides an accessible, productive framework in which to discuss possible structures for all manner of oral and written work. True, only some of the 'Ways' draw on genuine Visualizations taken from science and mathematics, while others may seem closer to cartoons, making it a kind of hybrid resource. Nevertheless, *The 13 Ways* – generated and refined in a four-year study of student essays and presentations, initiated during a Royal Literary Fund Fellowship at Oxford Brookes University – became an invaluable and flexible tool for students and staff there, forming part of a thriving study skills module in the Department of English Studies. The chart can be downloaded (with supporting notes on its application in class) via the *Writing* section of the Royal Literary Fund's website [Petrucci, 2005]. What counts here, once more, is not any definitive or exhaustive quality in the chart, but what it achieves in practice. I am thinking, for example, of that precious clarity between tutor and overseas student when either of them can point to one of these images and make herself finally, completely, understood.

VI.   THREE CLARIFICATIONS

I must address a threesome of tricky issues somewhat skirted around in previous sections, deferred until now so that the reader could first broadly grasp the concept (and some trial examples) of Visualization.

- The distinction between *Visualization* and *visual analogy*;
- The distinction between *diagram* and *Visualization*;
- The use of text (titles, annotations, captions, etc.) within Visualizations.

Taking these in order: to what extent are my terms 'Visualization' and 'visual analogy' analogous? To answer that, I must revisit my earlier observation that the pilot Visualizations in this paper have "the inbuilt character both of an analogy *and* of a scientific Visualization". I somewhat circumvented, there, the subtlety that, strictly speaking, a Visualization is a representation *of* a situation, while a visual analogy is a representing object applied *between* situations (i.e. from source to target). Thus, a Visualization is not *necessarily* an analogy. A strange magnetic field pattern, for instance, does not automatically (or obviously) stand for anything else: it may be wielded elsewhere, *as* an analogy, but only if fit for that purpose. Likewise, some visual analogies are merely pictorial or whimsical, lacking the structural rigour of a good Visualization – I therefore tend to reserve the phrase 'visual analogy' for a more general analogic approach using images that might not always qualify as clear or strong Visualizations. It follows that the two terms really denote overlapping (rather than interchangeable) concepts, with my special sense of Visualization occupying the central portion below [15].

VISUALIZATIONS that are <u>not</u> obvious analogies | VISUALIZATIONS that <u>are</u> good analogies (and vice versa) | VISUAL ANALOGIES that are <u>not</u> strong Visualizations

Moving to the second point, I am entirely comfortable with the idea that a diagram, in its original sense, offers an abstract representation of the relation of its (often observable) elements: it is therefore – at least in *that* respect – a *bona fide* Visualization. Many diagrams involve conceptual mapping, can communicate connections between abstract qualities, or illustrate structural relationships between their constituent parts (think, for example, of diagrams as deployed in geometry or, indeed, the Venn diagram). However, from apparently straightforward etymological origins [16], the term has grown complexly varied: inspecting the entire spectrum of contemporary diagrammatic types, along with their various semiotic roles, one cannot ignore the widespread use of 'diagram' to denote the merely illustrative (a near-photographic or pictorial likeness, a representational sketch or simplification). I bear that humble word no malice; but my more specific term 'Visualization' makes clear (as demonstrated in the iron filings example) that some essential correspondence must exist between the visual abstraction and the behaviours of the elements it represents – i.e. features of the subject's underlying, intrinsic properties should be preserved in, or imitated by, a Visualization. This newer term thus sits comfortably with the analogic processes I seek to develop, whereas commandeering the portmanteau 'diagram' for the purpose might lead (given its plural use) to misunderstanding [17]. For those needing to further distinguish between the two: a Visualization may be called (colloquially and loosely) a diagram; but a diagram or illustration is not perforce, or *per se*, a Visualization. A diagram or sketch of the benzene ring Kekulé saw in his dream [18] reflects the relevant characteristics of carbon valency in its spatial structure; a pictorial diagram of some benzene sitting in a flask does not. Only the first of these operates as a Visualization. Actually, several of my own figures might be considered closer to embellished flow charts or diagrams than to scientific Visualizations: although all my analogies visually capture (or include) aspects of the scientific/ literary process being considered, how far does each really *encode*, visually, the properties of that process (see the second half of [15])?

Taking up the final issue in the list, some readers may be troubled by the fact that my analogies are not purely visual: they are, to various degrees, annotated with text. Am I cheating? To some extent, yes; but scientific Visualizations are normally labelled or captioned in similar ways. In these, and in (I would hope, most of) the figures presented here, some vital aspect of information (structural or interpretative) is still stored in the image, through the visual elements themselves (including their internal spatial relationships and external associations). The textual labels are generally semiotic adjuncts: in the main, they merely name (identify), clarify or extend the visual elements they accompany. Where my figures do seem girded with explicatory tags, this is usually to make them more intelligible to a wider range of readers, including non-specialists. Such notes and captions often become redundant when a Visualization is part of common visual currency, or when a tutor has previously introduced the Visualization or is talking it through, or where the students who formulate a visual analogy are already au fait with its subject and frames of reference [19].

VII.   SCIENCE and LITERARY STUDIES: TWO-WAY TRAFFIC?

The rich ancestry of visual analogy across culture shows that brains are not merely describing mechanisms or 'reality detectors', but deep-pattern-deducing organs. This is certainly evident in science, which abounds in metaphor/ analogy relating to many other areas of human experience (black *holes*, quantum *wells*, electric *current*, electron *avalanche*, etc.) [20]. In recent decades, with the popularisation of science, the activity has intensified (who is not now familiar with the analogy of billiard balls for molecular collisions in a gas?) [21]. The specific utilisation of literature, though, by the sciences has been largely confined to quarrying (mostly classical) references for the purposes of naming – as with the elements of the Periodic Table, or the commandeering of 'quark' from *Finnegans Wake*. Analogies of a *visual* nature are not sought, as a rule, within literary discourse for explanatory use in science. I note a similar asymmetry in my own research, where a number of science-based Visualizations have been found with which to profitably explore literary themes, while the reverse has not yet come about. I propose below two main causes for this asymmetry, each consisting of factors of varying obstinacy:

- There is a historical, perhaps inherent, lack of *true* Visualizations in literary studies [22];

- Most literary visual forms (where these *do* occur) are unsuited as analogies for scientific discourse [23].

The obvious response to the first point is to strive to nudge open a few more doors on Visualization within literary studies. Some readers might object that visual representations already exist, in force, within the humanities [24]. Certain fields (such as media studies) are well stocked with visual

elements, formats, tropes and types: graphs, flow charts, 'Eye Q', Sue Palmer's skeletons [2001], analogies linking film and drama with literature, 3D collages, and so on. True, some models in media studies and communication theory do indeed operate through visual analogy or possess some quality of Visualization; when it comes to literary discourse, this is far less apparent. Naturally, I cannot argue the case instance by instance: my general claim is that many of the visual items deployed in literary studies – even highly-structured charts and images – are essentially diagrams in the pictorial sense described in the previous section, performing acts of visual list-making or description. The ubiquity of tools such as spider maps and the graphic organizer may be evidence of strong visual literacy in our educational culture, but does not represent a widespread use of Visualization. I maintain, then, that most areas of literary discourse specifically, if not the humanities more generally, employ true Visualizations (and visual analogies) relatively rarely [25]. The arguments for the first bullet point ramify into the second. While it is clear that charts and diagrams – as commonly found across the sciences (e.g. for presenting data) – do occur in many other areas of discourse, those generic forms seldom possess the depth of visual structure that might usefully imitate actual scientific phenomena [26]. They are therefore of little value in science as analogies.

There are further issues to consider. Whenever a visual analogy is bridging disciplines, some appropriate level of understanding and clarity has to be established at *both* ends of the bridge for it to carry any weight of traffic, or if serious backfiring of the analogy is to be avoided. Einstein remarked [27] (quoted in Østergaard [2006, p.261]): "After a certain high level of technical skill is achieved, science and art tend to coalesce in aesthetics, plasticity, and form. The greatest scientists are always artists as well." While such coalescence is terrific news in the context of this paper, I am nevertheless tempted to ask whether Einstein was equally convinced that the greatest artists are always scientists. Even if (in some sense) they *are*, we cannot ignore his caveat concerning the "high level of technical skill" initially required before the merging can occur. It needs no Einstein to see the snag in relating science and the humanities for those whose science and mathematics are weak. In fact, non-scientists may experience problems when *either* end of a bridging analogy relates to the sciences [28]. One can even venture that scientists might be stronger protagonists in any increased traffic with literary studies: while they can be expected to get the gist of most literary ideas, even experts in literary discourse could struggle with (what would be to a scientist) fairly basic science and mathematics if they do not possess the required cognitive codes. Science might also drive the enterprise more prominently or successfully, owing to the relative receptivity of literary discourse (its large cognitive bandwidth, if you will) for scientific Visualizations, as demonstrated by the figures earlier [29].

I frequently think of the above difficulties as akin to those of procurement and rejection in an organ transplant [30]. It is premature, though, to conclude that such problems are fundamental or terminal. To begin with, not all literary discourse is text-based and discursive, while not all science is purely mathematical. Even where mathematics does reign supreme, there may be scope for transposition into clear visual representations (as with the Feynman diagrams of quantum mechanics) or some inventive paraphrase into words and images that provide a more suitable basis for analogy. As for attaining the abovementioned "appropriate level of understanding and clarity" in the science, Cordle [2005, p.7] reminds us that scientific discourse is a powerful generator of narratives that do not always accurately represent professional science: "Those narratives are for many of us, as non-scientists, translations from a language we do not fully understand". Given that so much of what the culture experiences as science consists of these simplified or incomplete translations, the non-scientist may be justified in exploiting their less rigorous (and less mathematical) forms to participate in cross-disciplinary dialogue. Thus, the need for specialist knowledge when formulating or applying scientific analogies may not be as crucial as one initially supposes, since scientific truth also resides in "the more culturally vital phenomena of Science and representation" [*ibid.*]. I retain deep reservations about allowing the science to become *too* flaccid in such analogies, but can see that interesting alignments might occur (whatever the degree of inaccuracy in the science) when popularised science engages with a non-scientific discipline itself concerned with cultural activity or representation.

I want to dispel any residual implication, either that Visualization can only give *one-way* nourishment at the science / literary studies membrane, or that any hierarchy, antagonism or adversarial state of affairs is intrinsic between these two fields [31]. In referring (earlier) to "bridging disciplines", I realise such images evoke a chasm; I hope the cost is acceptable, given how succinctly the metaphor reflects the subject separatism still encountered – perhaps too often – in schools, colleges and careers. That said, cross-disciplinary exploration should not seek to merge, utterly, its targeted areas of activity, nor try to discover some Shangri-La of a common language between them, but might better

aim "to be more attentive and sensitive to difference... to look for *the possibilities of exchangeable and changeable modes* of communication and understanding" [Pope 2005, p.190; my italics]. This recognises that the sciences and humanities (as Gould [2004, p.6] puts it, for science and art) "cannot be morphed into one simple coherence... but the two enterprises can lead us onward together... toward the common goal of human wisdom, achieved through the union of natural knowledge and creative art" [32]. The idea that cross-situational pattern recognition may form the very armature of thought itself, with the roots of words themselves tangled in visual metaphor, should be read as an encouraging initial sign for anyone wishing to contribute to this union through visual analogy [33].

There is a pivotal point to add here, one that may address the relative absence of Visualizations in the literary domain. At the opening of Section IV, I claim that my figures represent:

> "...analogies that qualify, to some degree, as Visualizations across disciplines: that is, they store, visually, some recognisable pattern of characteristics, some parallel set of relationships, however basic, which illuminates not only the sourced (scientific) situation but also the targeted aspect of (here) textual reception."

This, as we have seen, describes a type of *analogic* Visualization, where a single Visualization relates to some aspect of Visualizability in the *target* as well as in the source (**Figure 9**). This double-ended quality to its Visualizing power is evidenced by the very fact that it works as an analogy. (It may help to recall, from the previous section, that Visualizations are not *always* analogies, and that "a Visualization is a representation *of* a situation, while a visual analogy is a representing object applied *between* situations".) Put differently: if a scientific (or any other kind of) Visualization operates successfully as an analogy for some aspect of literary studies, it must also be (to some extent) a *literary* Visualization. Thus the activity of this paper is actually creating (or discovering) a source of potential Visualizations for literary discourse.

VIII. DANGERS; OPPORTUNITIES

Visual analogies have potential pitfalls. For instance, how do we prevent student responses from unravelling into easy, arbitrary or gratuitous speculation? Without guidance, a study based purely on analogy (visual or otherwise) can quickly become all locus and no point, a bubble-bath of froth, lacking substance. Bad analogies spawn to outnumber the good: the former lead to confusion and false concepts; the latter are, at best, only ever partial (all analogies have an elastic limit). Like metaphors, analogies can be over-extended, inappropriately mixed, or poorly made. One sees, already, for certain difficult topics, 'explanations' that are quagmires of half-glossed analogies and metaphors, recycled by users oblivious to the misunderstandings they propagate. In inexpert hands, then, visual analogy might actually serve to cloud or misrepresent any Visualizabilities present in the text. Besides, how does the Bohmian credo – here, that all aspects of analysis and Visualization connect at some deep level of *Implicate Order* – help us one jot in the Explicate world of the classroom? What happens, for example, if we cannot trace (or intuit) the connective paths, or verify them? How do we establish reliable theoretical centres against which to test results? Might the novelty of visual analogies tempt us into neglecting perfectly adequate conventional methods? Why not let texts, and their concepts, simply reveal themselves, unmediated, as they have always done?

Although none of these objections is in any way impertinent, one should recall that similar problems do occur in more established modes of theoretical and educational discourse. Just as an analogy can be taken too literally, so theories and models can be deployed with excess rigidity; they, too, are incomplete in their representations; and all theorisation and modelling, like analogy, must acknowledge its bounds. Literary discourse, we know, is not immune to speculation, poorly formulated ideas or misrepresentations of text. So, given that existing modes of literary criticism are not about to be overturned by this paper, why not experiment (where suitable and possible) with a more thoroughgoing analogy-centred pedagogy? I am not claiming that literary or educational discourse is utterly devoid of visual stimulus, nor do I wish to supplant or weaken any element of textual appreciation *via text*; I simply hope to appeal to students' visual faculties with refreshing alternatives (where needed) to academic screed, particularly where opportunities exist for departments to draw creatively on a number of subject areas. After all, whether we like it or not, students are increasingly reliant on visual input – or, put more positively, they are becoming more visually adept in (what has been termed) 'the visual turn' [Jewitt, 2008]. Raised on various types of screen, they regularly learn and retrieve information via VDU and in multi-media/ multimodal contexts [Kress &

van Leeuwen, 2001], making the educational advantages of visual analogy difficult to ignore (an observation, I must stress, that in no way implies we should thereby neglect books and reading).

Clearly, not all visual analogies are of immediate value in any given context, and some steering of the exercise is essential. The ideal is to discover those that strike us as having about them a rightness which repays closer and repeated inspection, just as the best metaphors do in poetry. However, even where the proposed analogy seemingly plies an arid segment of conceptual space, or when the analogy-making activity falters at an early stage (with or without some initial connection having been made), we will still have involved the student in invention across the disciplines, in imaginative intellectual play. Moreover, testing those analogies for aptness and usefulness serves as more than a safeguard against arbitrariness: it fosters critical judgement and the ability to detect, define and assess conceptual patterns. There is no reason why this testing process cannot be extended (particularly with capable groups) so that several visual analogies are constelled around a single idea, with each helping to correct any errors or misunderstandings generated by the others, thus providing a sophisticated interactive learning method. Other potential gains from implementing visual analogy (in the tertiary sector) include: the development of a novel tool to supplement more established modes of description, analysis and argument; a fresh supply of accessible introductions and explanations (even for tough terrain, if properly done); and a growing stock of enticing visual resources for undergraduate/ postgraduate workshops and seminars, to spur participation and enrich discussion [34].

A major aim, though, in deploying visual analogy within literary studies, is to contribute to a cross-disciplinary pedagogy that is creatively, as well as critically, engaged. For me, it extends a radical strand (into the visual domain, and across disciplines) of forward-looking critical-creative and 'rewriting' practices [Pope, 2002]. Certainly, presenting creative writing students with a scientific Visualization (with or without explanatory annotation or supporting scientific context) can facilitate outcomes that draw on its visual/ conceptual/ metaphorical cargo in profound and startling ways, inspiring work that a spoken or written reference to the scientific idea may not, I suspect, have yielded. Also, any discipline (not just science) can become (in principle) a source of Visualizing analogies, opening up a flush of cross-disciplinary and cross-critical research opportunities which, in the longer term, may lead to innovative hybrid theories, generate new sites of Intertextual discourse and expand creative-critical fields by freeing up their energies for staff and students alike. In fact, I support the heuristic investigation of cognitive-creative overlaps between all activities, across the board, however incommensurate their methods and/or semiotics may seem (trigonometry and essay writing, say). The alternative is to accept – by implication, if not overtly – that disciplines and specialisations (including 'creativity' and 'criticism') developed in response to some *inherent* structure in knowledge that resembles a sequence of separate, largely self-sufficient strands. Any such hypothesis (explicit or tacit) of ultimate separateness should, as in empirical science, be constantly, inventively challenged.

Meanwhile, this work has already been harvested by the British Council to introduce to overseas students (with scant training in science and, often, even less English) such concepts as Intra-textuality and the filter analogy for translation [Petrucci 2001a]. When severe language (or subject) barriers are faced – in fact, *wherever* students need initial support with unfamiliar 'languages' such as mathematics or arcane terminology – visual analogy sometimes has an edge over text-based explanations. The visual dimension of Visualizations can even function autonomously (i.e. beyond technical content), in that users commonly express excitement about them as aesthetic objects *in their own right*, an aspect that may be harnessed for less motivated students. Suitably developed, visual analogy could therefore supply a flow into education/ theory of original, flexibly experimental and aesthetically appealing ideas, attractive not only to those intimidated by reams of closely-argued text but also advanced students thinking of taking the approach into postgraduate study. This student-centredness is key. There is a democratic, personalised feel to visual analogy: it encourages individuals to excavate their own expertise and interests, is fluid and adaptable, and accommodates non-linear, interactive modes of learning. Handled well, it is unthreatening, participatory, creative and (more often than not) fun.

Of course, much of the activity I propose is unrealised or (as yet) somewhat invisible; but the importance of analogy-making in teaching has not gone unnoticed. Gilbert et al. [2008], for instance, note the role of analogies (in the context of 'visualization' as they define it) in science education, while Nottis & McFarland [2002] register the essential part analogy plays in broaching scientific concepts in schools – and stress the need to acquire the skills involved in using it well [35]. What is more, visual analogy seems to be especially advantageous when presenting highly abstract ideas, providing a cognitive stepping stone from which the final, clinching leap can then be made. It

therefore makes good educational and pragmatic sense to further research how best the methods of visual analogy may be progressed and expanded, not least in subjects where its use is still uncommon [36]. In literary discourse, it should by now be clear that the rewards may have less to do with theoretical rigour than with liberating staff and students to engage in interactive projects that explore, anew, the informing processes of (say) language, translation or poetry. In its outcomes, my use of visual analogy makes no pretence at scientific definitiveness or unassailability: within an open teaching context, it tends to emphasise radical, risky sites of discourse as opposed to pre-determined canons delivered in top-down fashion.

With due respect for difference, such work may also help to dissolve the (often artificial) humanities-sciences split [37]. Indeed, the successful application of cross-disciplinary Visualizations could bring notable insights to a world increasingly aware of its complexities and interconnectedness. I recall, here, Thomas Young, who devised the famous double-slit experiment to test the wave behaviour of light, but also had a hand in deciphering the Rosetta Stone. Kekulé, one of the founders of structural organic chemistry, trained as an architect. These, I suggest, could be more than isolated instances of excellent, polymath minds being able to make separate incursions into disparate domains: they may be profound evidence that the discursive, deep recognition of patterns is a transferable skill (*across* subject matter as well as language types) that can amplify the faculty of discovery across all the disciplines. Where literary discourse is concerned, I borrow an injunction from radical ecology: to challenge compartmentalisation; to continually question any absolute priority given to measurability, to rational or mechanistic modes of analysis, particularly where the full range of human sensitivities and values is thereby excluded. With literary texts, too much rigour is rigor mortis. Not that those analytical modes are worthless, or that pure rigour is not, in its proper place, as insightful as it is essential, or cannot itself serve (in certain quarters) as a welcome antidote; it is just that such processes, alone, fall short (or bring us up short) of the whole experience – the life experience – of a text. Visual analogies in general, and Visualizations in particular, by no means complete that experience; but, used with discrimination, and provided they do not get out of hand, they offer a vital new meeting place in education and thought, helping to span the creative-critical divide in crucial ways. Writers and speakers in all educational fields have always deployed analogic devices: the various types of analogy realised in this paper, and the interactivity between creativity, aesthetics and reason they tacitly endorse, merely extend that age-old undertaking in a multidisciplinary manner. Within a galvanised, progressive pedagogy, these visual modes encourage staff and students to explore, then cross, the erected borders of creative discourse, guiding us away from any Procrustean dominion of models.

*9 800 **words** (main text)*
*17 200 **words** (complete paper)*

ENDNOTES

[1]   As my early work on science-based analogies began to mature, I found Kant's distinction (between *sensation* and *intuition*) compelling; but I drew on him rather loosely and often through other writers. There is therefore little value (in the current context) in going into the nuances of what the terms mean, precisely, in Kantian philosophy or how those meanings later evolved (importantly) through physicists such as Heisenberg [Miller 1996, p.69]. A brief (and accessible) alternative description of Visualization vs. Visualizability (along broadly Kantian lines) is given in Muldoon's [2002] discussion of Arthur I. Miller's work. In its detail and connotations, my own interpretation of the terms differs from this.

[2]   'Text' in its limited sense of print in books, articles, etc. (i.e. 'words on the page' or 'the text in itself').

[3]   One might suppose, then, that creativity itself can be traced back to this universal source. Reserving judgement on whether or not creativity can really be studied, as it were, raw [Petrucci, 2001c], one can at least postulate (along Bohmian lines) that, if we were able to go ever deeper into its processes (expressed across the disciplines as well as within particular genres), we would find the various hues of creativity also merging towards a common complexion in an underlying continuum of complex, unfolding experience.

[4]   When I say 'reception' or 'textual reception', I am not alluding to any Reception Theory or Reader-Response literary theory *per se*, just the general processes of a text being received by/in its reader/listener.

[5]   Having formulated this notion in some detail, I discovered much later that Bohm's closing comments in *Wholeness and the Implicate Order* touch on something similar. He suggests that any development of his "proposed views concerning the general nature of 'the totality of all that is'… becomes itself an *active factor* in the totality of existence which includes ourselves as well as the objects of our thoughts and experimental investigations" [1983, p.213].

[6]   This is not to say that analogy and simile/ metaphor are analogous! *The Shorter OED* [1973] defines analogy as "equivalency or likeness of relations", or (in logic) as "resemblance of relations or attributes as a ground of reasoning" (or, more precisely, "presumptive reasoning based on the assumption that if things have some similar attributes, their other attributes will be similar"). Metaphor, however, is the (often implicit) way in which "a name or descriptive term is transferred to some object to which it is not properly applicable" [*ibid*.]. Of course, metaphors operate differently in science and literature. Literary metaphor attempts some aspect of comparison (however wild or sedate), but the terms of that comparison are mostly unclear, and its target can be vague and suggestive as well as specific; moreover, in literature, an *obvious* metaphor is often considered poor. A scientific metaphor, though, must have clear terms of reference and is tested to check that the similarities with its subject function well and repeatably. As for simile, this involves a more explicit "comparison of one thing with another, esp. as an ornament in poetry or rhetoric" [*ibid*.]. I am not sure I appreciate 'ornament' here, given the profound and revealing qualities of an apt simile; also, the poet in me fiercely contests that 'properly' applied to metaphor, not least on the grounds that an appropriate or convincing likeness must be apparent, at some level, for any metaphor (or simile) to be considered a good one. Caveats aside, we might summarise as follows: in simile/ metaphor, one thing is made to stand in for (or is named or seen in terms of) something else; an analogy, on the other hand, usually implies that a more extensive or systematic comparison of respective qualities is being made. I do not claim this distinction as universal; but it will do here.

To finalise the picture, I need to clarify 'model'. *The Shorter OED* [1973]: "Something that *accurately* resembles something else" (my italics). More pointedly, in *The Concise Oxford Dictionary* [1999]: "a simplified description, especially a mathematical one, of a system or process, to assist calculations and predictions". Miller [1996, p.223]: "Models are approximations enabling scientists to grope their way toward a theory of some physical process, or they are simplified situations permitting application of a general theory". Clearly, the analogies conceptualised in this paper are *not* oriented principally towards 'a theory of some… process', nor do they offer simplifications 'permitting application of a general theory' or 'to assist calculations and predictions'. They may depend upon (or constellate within) my interpretation of Bohm's ideas, but they do not *model* that interpretation. They are more discursive and suggestive, and are less concerned with accuracy, than most models (as defined above), and seek to open up a greater play of possible kinships. Which is not to say that models and analogies/ metaphors are entirely unrelated (J.T. Black: "Every metaphor is the tip of a submerged model" [quoted in: Miller 1996, p.223]), or that some Visualizations (even as I describe them) could not become so convincing and rigorous as to approach models in certain core respects (see below); it is more that the modes of analogy/ Visualization espoused here tend to emphasise qualities of inventive connectivity over those of predictive rigour.

The above (somewhat selective) definitions are not aggregated towards anything definitive. Miller [1996, p.252], for instance, puts his cat among my distinctions by saying that "models are metaphors that can function like analogies" (a statement which is itself a simile!). But perhaps I do establish some basis for my suggestion that the processes by which simile, metaphor and analogy engage with comparison have more in common with one another than with the methodologies of theoretical modelling. I realise that *scientific* metaphors and analogies are often mobilised with the intention of providing actual or approximate models; but my slant on Visualization attempts to soften that aim by running a little closer to the literary sense of metaphor, providing a space that is not overwhelmed, *ab initio*, by the predictive agenda. My hybrid position may seem precarious at times, but I believe it to be essential in opening up new analogic territories between the disciplines, particularly in the early stages of such activity. Certainly, to *always* insist on an analogy's absolute scientific accuracy (something a non-specialist might find difficult to achieve or confirm) would probably quell this project's interdisciplinary potential from the outset. Also, keeping the exercise creatively unshackled gives us the chance that some analogies may do more than merely *reflect* the links and similarities between disparate subject areas, going on (as with metaphor in literature) to actually *create* correspondences.

I still need to refine my position, though, by noting that analogy (as with simile and metaphor) can vary in strength. A weak (or loose) analogy tends to be superficial and approximate, or (perhaps) simply serves a symbolic function; indeed, it is often little more than an interesting simile or metaphor. It focuses on the *exploratory*, or suggestive, role of analogies and, on the whole, shares very little with theoretical, predictive models. Meanwhile, a strong (or close) analogy possesses rich correspondences, and the parallels operate at depth; it tends to emphasise the *explanatory* function of analogies. The Visualizations of Section V illustrate how the sophistication of analogies can be increased enormously; but I stop short, even there, of claiming for them the status of models. However, I concede here that *very* strong analogies, if highly developed, might be considered close cousins to models, bringing us within reach of the scientific sense of analogy/ metaphor. Another way of approaching this is to extend the concept of metaphorical 'tension' [Miller 1996, p.221] to analogies: the greater the gap (tension) between an analogy and what it is applied to (i.e. the greater the *apparent* dissimilarity), the greater the creative potential of that analogy. Where the tension is low (i.e. the connections are clear and mostly accepted), the analogy is not a great departure from what is already known and understood, and it may (if suitably developed) then take the form of something akin to a model.

It would be fascinating to pursue the distinctions further into that extended family of likeness-making (simile, metaphor, symbol, parable, allegory, myth, fable…) of which analogy is just one member; but such discussions are well beyond the scope of this present paper. Nor is there space to lay out, for the interested reader, the

extensive scientific/ philosophical literature exploring the significance of models and analogy in science and education (see, for example, Gilbert et al. [2008]); the above notes merely attempt a few specific clarifications.

[7]   Bohm [1983, p.179] himself deploys an analogy involving ink droplets and glycerine in a glass-cylinder device, to help us 'see' his new concept of *Implicate Order*. It should be borne in mind, however, that although he employs this to get us going, he is just as keen to establish its inadequacies as an analogy.

[8]   I favour this inclusive approach to Intertextuality because it enables users to explore their own interests and interpretations or, if they would rather do so, to focus in a more academic way on any standard or classic definitions of the term.

[9]   To highlight the limitations of analogies such as these, I often apply a mountaineering analogy to the spectrum analogy (with the aid of a figure not reproduced here). First, imagine traversing a mountain range. Not only are there the four dimensions of space and time, but all the other 'dimensions' (I use the term somewhat vaguely) of weather, your shifting mood and physical-psychological condition, the inputs of walking companions, and so on. All these dimensions are interwoven and difficult to summarise in visual form. You could retrace your journey, later, on a 3D model; or project it onto a contour map in 2D; or just plot your height above sea level along an axis (time) as a curve of peaks and troughs that look a little like Figure 2. You would never say, however, that a particular segment of that plot precisely re-created your journey at that point; neither would the plot, taken as a whole, yield anything more than a hugely simplified (though, in some contexts, quite helpful) representation of your overall experience. This analogy, itself, has its defects (unlike Figure 2, its variables – time and height – are precise, continuous and verifiable), but it does serve to bring the point home.

[10]   This Intra-textual end of the spectrum can be interpreted as highlighting textual qualities and content that are progressively more difficult to place than the conspicuous sources of Explicit Intertextuality. It may be seen, perhaps, as an increasingly diffuse area that gathers, in Intertextual terms, aspects of text for which the idea of provenance becomes uncertain, partial or effectively meaningless, including low-level linguistic codes and the very fundaments of sound. Rather than a pre-defined, well-delineated concept split off from some more general notion of Intertextuality, it offers (as does the spectrum as a whole) a negotiable site of discourse [Petrucci 2001b, p.10]: "… the Intra-textual regime is essentially speculative, provisional, hypothetical, empirical: as a consequence, the term remains usefully open to interpretation, conflicting theorisations and practical explorations."

[11]   "The continuum itself consequently becomes a new site of Intertextual discourse centred on the text" [Petrucci 2001b, p.10].

[12]   'Intertext' denotes, loosely, any item of Intertextuality. 'Context' is as discussed by Pope [2002, p.246]: "all those physical and cultural conditions whereby a text – or, for that matter, anything else – comes into being".

[13]   For Jakobson's model see, for instance, Selden & Widdowson [1993, p.47]. I represent it as follows:

JAKOBSON MODEL		*context*		
		message		
addresser		*contact*		addressee
		code		
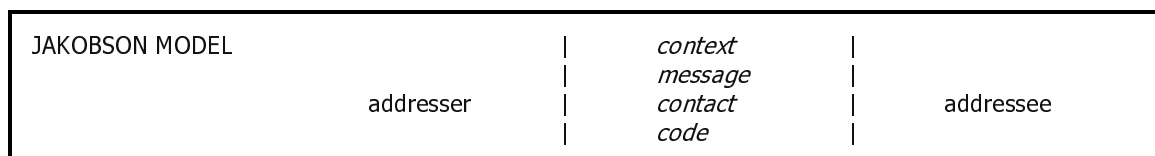
[14]   Figure 7b imitates the form of frequency response spectra found in electronics or when mapping out the transmission characteristics of a complex light filter. Actually, the way it is used here is more accurately described in terms of an *amplitude response spectrum* (one that might also have – unlike an optical filter – amplifying aspects to it). Physicists and engineers will recognise such spectra as close relatives of the Transfer Function applying to electronic circuits or optical instruments. Note that the spectra of Figure 7 are not set up to deal with the specifics of any particular case: they merely provide a plausible form for generic discussion on how the approach might work. The analogy, as shown, is thus not intended as a detailed analytical tool.

[15]   Having made (and, now, drawn) this distinction, I appreciate that in many teaching situations the terms *Visualization* and *visual analogy* might be allowed to merge, at least initially. Nor is it any great offence if *scientific Visualizations* are called *scientific visual analogies*. After all, all the concepts I attempt to clarify (Visualization, analogy, model, metaphor, simile, diagram) are to varying extents motley and elastic, their meanings shifting with context, praxis and the particular type (or specific example) under scrutiny. I wish to highlight the spaces between them, to prevent them from sliding into mutual substitutability; but, for anyone struggling to see the precise nature of (or, even, any point in making) such distinctions, or for whom the more essential issue is praxis, I suggest these subtleties be dropped. Indeed, astute readers will note that, in my own discussion of the figures, I am quite fluid in my use of *Visualization* and *(visual) analogy* (the 'visual', where unstated, is usually implied). This is partly because those visual forms are relatively new and their strength as Visualizations – to be frank – not yet fully established. So, although I would propose all the figures as palatable visual analogies, I cannot be as forthright regarding their potency as Visualizations. The Venn diagram, electromagnetic spectrum and translation filter, in my opinion, pass at some level; the bubble rafts, though,

cannot be drawn on paper so as to render their multi-dimensional overlaps in cognitive space: hence, do they *really* succeed as a Visualization (come to think of it, neither do they parallel real soap bubbles in their behaviour – so, how well does the *analogy* work)? Other figures might also be thought a little tenuous: the bulk of the science behind Figure 4, for instance, is not really present in *Visualized* form, meaning that the figure may in fact be more akin to a diagram or flow chart. However, the aim here is to get things moving, to demonstrate the *principle* that certain scientific concepts lend themselves, quite straightforwardly, as workable visual analogies (and, perhaps, as Visualizations) across disciplines. A weak degree of Visualization in an analogy is not necessarily detrimental to its worth or interest, and I do not wish to burden potential users with the feeling that any analogy they devise *must* also be a gilt-edged Visualization. That said, I invite fulsome challenge on the extent to which each of my examples actually does succeed as a Visualization.

[16]   From (Latin) *diagramma* / (Greek) *diagráphein*: meaning 'mark out by lines'.

[17]   Ironically, 'diagram' can also connote the opposite problem: that of closure. In its scientific incarnation, it suggests a nailing down of interpretation rather than any opening up to it. In a way, the scientific diagram aspires to the model rather than the analogy (see Leg 3). It strives for a definitive explanation and is usually considered inadequate if it leads to multiple or conflicting readings. On the other hand, a scientific Visualization – applied across disciplines as a visual analogy – makes room for interpretation, creativity and intuitive extrapolation. It can facilitate inventiveness and unexpected insight *between* source and target, as much as understanding in the target subject itself. Naturally, it strengthens matters if any proposed correlations between a Visualization and its target are (to some degree) convincing and uncontrived; but (as we saw with the spectrum analogy in Section III) few, if any, scientific Visualizations will be able to parallel or model any given area of literary discourse *precisely*. Thus, 'diagram' (especially as understood among scientists) raises, for me, all the wrong process expectations.

[18]   The German chemist August Kekulé (1829-96) arrived at the ring structure of benzene (he claimed) during a dozing reverie in front of his fire, in which he had a vision of a snake consuming its own tail.

[19]   This assertion – that notes and captions may be understood, or are redundant, for Visualizations in some contexts – may be seen as a sleight of hand to cover up the fact that they actually continue to be present (i.e. we simply read in the annotations implied by a familiar/ stock situation, or 'relocate' the explanatory texts as speech). This does little to weaken my overall point. All representations (visual or textual) require context in order to make sense, to achieve their associative values in each particular case. '821.914' can be a decimal number to a mathematician, or a shelf mark to a librarian (the Dewey Decimal Classification for 'English Poetry: 1945-1999'). Visualizations (scientific or otherwise) similarly rely on their contextual tags (whether these are written down, spoken, or taken as understood) in order to operate cogently under the desired conditions. The occurrence within Visualizations of words or word-based signifiers, where they help the context to be established or clarified, or when they serve to raise or emphasise particular issues, is therefore broadly in keeping with the conventions of applied, analytical imagery.

[20]   It may be that science, in spite of its strong mathematical basis, can raid other fields of physical experience for likenesses because its processes and outcomes relate predominantly and directly to that physical world where so many metaphors and analogies originate.

[21]   In fact, some visual images in science are now so widespread that they have become layered, or are 'recycled', within the culture, as when the Visualization of our solar system is adopted, in schools, as an analogy for the atom.

[22]   In saying that the long and fruitful lineage of Visualization (and, by association, of visual analogy) in science has little counterpart in literary discourse, I am *not* claiming that non-scientists do not arrive at creativity and originality through visual means. A physicist or a novelist can, equally, crack a technical problem through an insight taking the form of a visual impression. John Fowles, for example, was often inspired by a vital image entering his mind. For *The French Lieutenant's Woman*, he saw a mysterious young woman standing at the end of a pier, gazing out to sea. Perhaps she stored, through her appearance and posture, as well as in her placement among the archetypes of the image, some metaphorical-structural code for the novel. In that sense, then, his vision may have had some properties of a 'literary Visualization', though it goes beyond this introductory project to investigate whether such codes could be made to relate, in any helpful way, either to science or to the concept of Visualization as developed here. I suspect that the *roots* of creativity may well be experienced across the disciplines in relatable ways, e.g. as tangible – and, not infrequently, visual – sensations; but the mere possession of a visual nature by those sensations does not mean (as we saw with diagrams) that they qualify as Visualizations. It is also fairly clear that such pictorial mental images as Fowles's do not lend themselves easily or immediately, even *in analogy*, to any technical area of science or mathematics.

In any case, literary discussion patently addresses words primarily through more words (though my somewhat obvious point is interestingly modulated by, say, the relationships between writing and the visual arts). To the various historical and semiotic reasons for this, we must add that literary analysis has not perceived any need for visual analogy or Visualization approaching that felt by technology and science (particularly the physical sciences). Science is imbued to its core by the drive to find the kinds of accurate and *repeatable* means of representation that Visualizations, as well as mathematics, amply provide. This has traditionally been fuelled, in

part, by its attempts (at least in its more basic material objects of study) to express and explain the behaviours of physical forms and phenomena. The fact that literary discourse mostly attends to the myriad (and, arguably, mixed/ discursive/ plural/ interwoven/ subjective) contents and concerns of texts therefore probably lies behind its scant utilisation by science as a source of analogy – and also goes some way in explaining the absence of literary Visualizations*. It seems likely that the objective, controlled study of repeatable (particularly physical) phenomena, along with the outcomes of mathematical procedures applied to them, lend themselves to Visualization in ways that are unavailable (or far less obviously available) to the cultural, psychological, reader-dependent insights of literary subjects. If true, this erects a grim, impenetrable context around my exhortation to "nudge open a few more doors on Visualization within literary studies"; fortunately, any inherent or universal lack of Visualizability in literary discourse is yet to be proved.

* *I should raise a potentially crucial caveat: that if repeatable, explanatory visual forms can be generated* in the mind's eye *through words alone, then a new, purely textual category of Visualization might apply to literary studies – an intriguing thought I cannot, I regret, pursue here.*

[23]   Many modes of literary discourse (e.g. the detailed content of a book review) are not easily reconstructed in non-textual (i.e. visual) forms that would apply straightforwardly to a specific scientific idea. Also, any migration of literary visual forms into science is hampered when the needs of the targeted scientific area are largely mathematical or couched principally in terms of equations (and a great deal of science relies on mathematics for its exploration, exposition and verification). Thus, even where a segment of literary discourse *is* somehow summarised or structured in a visual way, this is unlikely to be received in most quarters of science, for the purposes of analogy, in any worthwhile or convincing manner.

[24]   I take the humanities to mean the wide range of disciplines and intellectual pursuits which include (in keeping with *The Concise Oxford Dictionary* [1999] definition): "learning or literature concerned with human culture, especially literature, history, art, music, and philosophy". The key thread tugged from time to time from this more general weave of subjects is that of literary studies, in particular the theme of textual reception.

[25]   I would expect this issue, if debated, to remain, nevertheless, somewhat grey – especially as the division between Visualizations and non-Visualizations, or analogies and non-analogies, is not always crisp.

[26]   Some simple examples should make this lack of 'visual depth' clear. A bar chart of a company's annual spending presents the data in an effective visual way; but there is nothing inherently bar-like in the dynamics of company spending. A pie chart might present a primitive aspect of analogy (i.e. a partition of goodies), but this really goes no deeper than a simplistic visual representation of relative amounts. For me, then, neither of these is a Visualization. Flow charts, however informative they may be, can also mislead in this respect. A flow chart of instructions for the manufacture of benzene, for example, might contain or invoke a good deal of data on benzene (boiling point, impurities, etc.); but – rather like a sketch of benzene in a flask – it offers little, if any, *visual* parallel for either the properties described or the procedural chemistry. Such charts may possess a distinctive spatial structure; but that structure merely traces the sequence or causality ('what happens next') in a narrative fashion. With visual modes such as the spider map, too, each specific application is often just a spatial (and therefore memorable) way of arranging lists or segregating information. There is some analogy (perhaps even a hint of Visualization) in the characteristics of a map or web; however, most images of this type are generic, and more or less pictorially engaged with visual description. A *good* Visualization, though, is rather like a good metaphor or analogy, in that it is "not merely descriptive; it is transactional and dynamic" [Wall & Tudor Jones 2006, p.467].

[27]   In a conversation with US writer and mathematician Archibald Henderson, in 1923.

[28]   To put this in a more positive light, at least any bridging analogies originating from within their *own* discipline might, in some cases, help literary students to comprehend target scientific ideas they would otherwise have trouble with (provided, of course, such analogies could be found). I should also add here that I am not suggesting any intellectual deficiency in literary students! The issue is one of cognitive access. There are regions of literary discourse in which the uninitiated scientist might also stumble.

[29]   This does not mean, however, that finding scientific visual forms to apply in literary studies is always a cinch. To begin with, the realm of mathematics and equations is not concerned so much with Visualization as with the rigorous and precise application of rules in the manipulation of symbols. Attempting to create visual abstractions from, say, Boolean algebra for use in literary criticism, from scratch, might engross specialists but is hardly student-friendly. Also, many visual representations in science are arcane, such as those in quantum physics whose sub-atomic behaviours are counter-intuitive (i.e. do not correspond to commonsense experience of the world): these are unlikely to mean much to a literature student unfamiliar with the science. Indeed, in attempting to deploy scientific ideas (at a fairly rudimentary level) as prompts for creative writing [Petrucci 2007, 2008], I myself encountered considerable challenges in keeping the scientific content of the exercises and diagrams *accessible* as well as accurate. One might ask, then: how is it that the highly mathematical, often abstract, domain of modern science is able to supply Visualizations for literary studies at all? Well, it would appear that – where Visualizations are concerned – literary discourse provides a good 'receiver', while science makes for an efficient 'transmitter'. The overall cognitive breadth of literary studies (a quality unreciprocated by the conceptual rigours in much of science) lends the science many potential targets. Meanwhile, scientific

Visualizations, I suggest, tend to map out a *specific* facet of conceptual space rather than an interwoven mass: this can, in a variety of cases, I suspect, be extended, paralleled or finessed into a Venn overlap with a suitably broad target concept or process, into which that facet can thus be made to transmit more cogently.

[30]   If any demand for literary Visualizations *were* to arise within the sciences, then, one would have to overcome problems both of 'rejection' and of finding suitable donors – which, to be more sanguine about it, could drive collaborations or encourage scientists with a literary arm to try to meet that demand themselves.

[31]   I re-emphasise, in broad keeping with Pope [2005, p.186-7] and Gould [2004, p.81-104], that any sense of conflict between the sciences and humanities – as exemplified, say, by the Leavis-Snow 'two cultures' quarrel or the 'science wars' (especially as whipped up around Alan Sokal's 1996 *Social Text* hoax) – is not only misconstrued and damaging, but also generally exaggerated.

[32]   One recent example of such a union – and an instructive outcome of the growing interest in the science-literature interface – was the collaboration between writer Alan Wall and particle physicist Gron Tudor Jones at Birmingham University. A major objective of their project was to examine, *inter alia*, "the extent to which scientific thought itself is based upon metaphoric or analogical perception" [Wall & Tudor Jones 2006, p.467]. Elsewhere, Arthur I. Miller [1996] has been making manifest the importance of visual creativity across science and art, while Daniel Cordle [2005, p.6] cites Gillian Beer [1983, p.7] in her assertion that "not only *ideas* but metaphors, myths, and narrative patterns could move rapidly freely to and fro between scientists and non-scientists", a position which, for Cordle, defines "a new form of interdisciplinarity entirely" which treats science not merely as part of literature's context within a history of ideas but as "a form *of* literature." Whether or not this overstates the case, it remains true that such workers are still hardly the norm; and, even where their projects are encouraged or debated, there are as yet insufficient means in place by which their insights can penetrate deeply into the structure or evolution of the departments and curricula of schools and universities. As ever, more research is called for; but we also need greater co-education/ cross-training of (and collaboration between) scientists and those working in the arts/ humanities, not least in what Vibeke Sorensen [2004] describes (when summarising Dr. Carver Mead on the lack of training in communication and conceptual-visual skills among scientists) as "the emerging field of Scientific Visualization…" – Sorensen's use of the term, by the way, not to be confused with my own – "…wherein visual thinking applies directly to many levels of the process".

[33]   We should also consider how languages having different alphabets and grammars can still interact through translation, because of their deeper semiotic correspondences; similarly, it should not be assumed impossible, particularly in a Bohmian world, for analogic links to be found between literary studies and the most arcane forms of science/ mathematics (which is why I would not dismiss, at this early stage, the potential for research breakthroughs in analogic Visualizations, even in the most abstract mathematical areas). It is interesting, for instance, how the theoretical branch of linguistics has absorbed so much advanced mathematics [Kracht, 2003], though it must be stressed that this does not employ Visualization but various mathematical and computational tools. It would be absorbing to also explore, here, the implications (for the creation of visual, and other forms of, analogy) of the 'linguistic turn' in philosophy, or Miller's reflection that "there is no distinction between literal and metaphorical meanings" [1996, p.219], or the assertion by Lakoff & Johnson [1999] that the broad functions of metaphor are fundamental to abstract thought; but I must limit my digressions.

[34]   One workshop exercise incorporating Figure 2 (and there are, of course, many variations on this) involves handing out a blank or sparsely annotated continuum (i.e. just the horizontal axis without any curve), along with two or three texts to be compared (there will have already been some priming discussion on the analogy itself). Tutors may also include a list of Intertextual attributes they wish to highlight in those texts. In small groups, or individually, students then utilise the blank continuum to map out one or more of the texts in ways that are pertinent to the context of the study, perhaps using different colours for each text. They then convene to argue points of similarity and difference in their various 'spectra', commenting on aspects of the process they found revealing or confusing. What insights might they have missed using the usual textual/spoken modes of analysis? Did the *visual* approach cause them to omit anything they might otherwise have seen?

[35]   "Metaphors are a means for explaining a poorly understood entity in terms of something the reader or listener understands better… But choosing the proper metaphor is the essence of conveying a difficult or abstract thought or concept with pungency and style" [Miller 1996, p.219]. The same might be said of visual analogies. For non-scientists, a donor Visualization from science may be less well understood than the host subject it is related to, which makes even more pressing the need to choose and deploy scientific visual analogies with care. Moreover, tutors and students do well to stay alert to the inadequacies (as well as fecundities) even of fine analogies. Good scientists are acutely aware that an analogy, for all its functionality, usually distorts the reality being illuminated: they test it to destruction, ascertaining exactly where and how the parallels begin to fail, thus preventing misapplication and seeking better analogies in the process. I would not want to see literary discourse aspiring to pseudo-science or flinging itself into scientific methodology at the expense of all it has achieved, but the inventive testing of visual analogies is one area in which non-scientists can learn from the *procedures* of science, as well as from its Visualizations. Part of the cognitive benefit of visual analogies, then, will involve trying to discern when, and why, they should be rejected, revised or (after initial insights) left behind.

[36]   This research might include: a trawling of the literary sphere for evidence of g*enuine* Visualizations; a survey of the current use of visual analogy across literary discourse; an examination of how such activity might be promoted and extended, particularly beyond the introductory stages of topics; detailed appraisals of sample visual analogies, with close monitoring of the changes they effect in understanding. Also, if analogies are of particular assistance when teaching abstract or difficult ideas (utilising a simpler, familiar trope to open up the unfamiliar, more demanding niche), then it is important to better grasp the problems behind finding suitable analogies and Visualizations in such cases. Thus, further research is needed to determine why, and to what extent, certain types of concept or idea (e.g. abstract theories) are less easy to represent *as* Visualizations – or to access *via* visual analogy – than others. Concrete phenomena, for instance, may be less awkward to work with, analogically, because they possess *observable* qualities. It would also seem reasonable to suppose that any difficulty encountered in Visualizing a more abstract concept may carry over into the process of finding less awkward Visualizations (from more familiar topics) that can provide (even approximately) an analogic match for it.

In making analogies, source Visualizations need to be found that are also adequate Visualizations of the target area. As Figure 9 suggests, if the analogy functions at all, there should be *some* resemblance there. A common approach, when visual analogies are hard to come by, or fail to stick, is simply to look harder, thinking of donor Visualizations that *might* work in analogy, then examining how far they succeed. I propose, for research, another method. Go straight to the target area itself and try to devise a Visualization for *that*. This might not happen or be possible, of course, or could demand an exacting proficiency in the target subject. The chances are, too, that what is generated is complex or arcane. However, if one meets with any success, even in a primitive or inexact fashion, one might then be able to work backwards: i.e. examine the target Visualization for any structures that resemble the Visualizations of easier scenarios familiar to students. In effect, one uses the more formidable *target* Visualization to look for clues as to what kinds of simpler, source Visualization might be pressed into service as analogies when teaching the target subject. One then assesses how far those candidate Visualizations actually succeed as analogies. Note: there is always the need to ensure that an analogy, whatever its means of creation, does not generate deeper problems and misunderstandings than it solves. Amending the source Visualization, and/or the manner in which the analogy is applied to the target, usually improves the fit.

I should add that, in researching this paper, I did not systematically scour the annals of science hoping to find source Visualizations to apply to literary discourse. Often, the process entailed calling to mind – and attempting to Visualize – aspects of literary studies I sensed might possess correspondences with scientific subjects whose Visualizations I already knew.   When it came off, those forms were then naturally termed 'scientific' Visualizations because it was the scientific context within which they were already established; for similar reasons, their structural features tended to be consolidated in terms of the science as well. On other occasions, the process was one of sudden insight – a cognitive leap that is, perhaps, somehow stored in the analogy itself and subsequently received by its user. What lies behind such leaps is, I suspect, some kind of simultaneity of conceptual traffic involving the relevant disciplines or topics. In much of this, I stabbed in the dark. The research I propose above might offer a better-lit background against which future efforts could be launched.

[37]   One such act of intermingling (of tremendous potential value) into which the objects of Visualization and the processes of visual analogy might pour, is the collaboration between science and the visual arts to research the possibilities (and limitations) of new modes of computer visuals (and underlying architecture) for the enhancement of computer-based creativity.

REFERENCES

Barthes, R. (1981) 'Theory of the Text', in: *Untying the Text: A Post-Structuralist Reader*, ed. R. Young, London: Routledge & Kegan Paul.

Beer, G. (1983) *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction,* London: Routledge; cited in Cordle, D. (2005, p.6).

Bohm, D. (1983) *Wholeness and the Implicate Order*, London: Ark/Routledge.

Bohm, D. (1996) *On Dialogue*, ed. Lee Nichol, London: Routledge.

Bohm, D. (1998) *On Creativity*, ed. Lee Nichol, London: Routledge.

Bohm, D. & Peat, F.D. (2000) *Science, Order and Creativity* (2nd edn.), London: Routledge.

Chalmers, D.J., French, R.M. & Hofstadter, D. [1991] *High-Level Perception, Representation, and Analogy: a Critique of Artificial Intelligence Methodology*, Indiana University [retrieved from the World Wide Web: 20 April 2009 at http://consc.net/papers/highlevel.pdf].

Cordle, D. (2005) *Metaphor Mongering: Science, Writing and Science Writing,* English Subject Centre Newsletter, issue 9, pp.5-9.

Dawkins, R. (1976) *The Selfish Gene*, London: OUP.

Deleuze, G. & Guattari, F. (1988) *A Thousand Plateaus*, trans. B. Massumi, London: Athlone.

Gilbert, J.K., Reiner, M. & Nakhleh, M. (eds.) (2008) *Visualization: Theory and Practice in Science Education (Models and Modeling in Science Education, vol. 3),* London: Springer.

Gould, S.J. (2004) *The Hedgehog, The Fox, and the Magister's Pox: Mending and Minding the Misconceived Gap between Science and the Humanities,* London: Vintage.

Hofstadter, D. (2001) 'Analogy as the Core of Cognition', in: *The Analogical Mind: Perspectives from Cognitive Science*, eds. D. Gentner, K. Holyoak & B. Kokinov, Cambridge MA: The MIT Press/ Bradford Book.

Jewitt, C. [2008] *The Visual in Learning and Creativity: a Review of the Literature. A Report for Creative Partnerships*, London: Arts Council England [retrieved from the World Wide Web: 19 April 2009 via www.creative-partnerships.com/literaturereviews].

Kant, I. (1934) 'Transcendental Doctrine of Elements: Part First – Transcendental Aesthetic', in: *Critique of Pure Reason*, trans. J.M.D. Meiklejohn, London: Everyman, J.M. Dent & Sons Ltd. [reprinted 1959].

Kracht, M. (2003) *The Mathematics of Language (Studies in Generative Grammar, vol. 63),* Berlin: Mouton de Gruyter.

Kress, G. & van Leeuwen, T. (2001) *Multimodal Discourses: The Modes and Media of Contemporary Communication*, New York: OUP.

Lakoff, G. & Johnson, M. (1980) *Metaphors We Live By,* Chicago: Univ. of Chicago Press.

Lakoff, G. & Johnson, M. (1999) *Philosophy in the Flesh: The Embodied Mind and its Challenge to Western Thought*, New York: Basic Books.

Miller, A.I. (1996) *Insights of Genius: Imagery and Creativity in Science and Art,* New York: Copernicus/ Springer-Verlag [reprinted 2000, The MIT Press].

Muldoon, C. [2002] *Did Picasso know about Einstein?* [retrieved from the World Wide Web: 1 May 2009 at http://physicsworld.com/cws/article/print/11359].

Nottis, K. & McFarland, J. [2002] *A Comparative Analysis of Pre-service Teacher Analogies generated for Process and Structure Concepts* [retrieved from the World Wide Web: 27 November 2002 at http://unr.edu/homepage/crowther/ejse/knottisetal.html & 1 January 2009 at http://wolfweb.unr.edu/homepage/crowther/ejse/knottisetal.html].

Østergaard, E. (2006) *Composing Einstein: exploring the kinship of art and science,* Interdisciplinary Science Reviews 31 (3), pp.261-274.

Palmer, S. (2001) *Skeletons for writing,* Literacy Today, issue 29; December [also retrieved from the World Wide Web: 1 January 2009 at www.literacytrust.org.uk/Pubs/palmer2.html].

Petrucci, M. (2001a) *Re-Writing in/and English Literature*, Proceedings of the 22nd All-Turkey English Literature Conference, 25-27 April 2001, held at Selcuk University (Konya, Turkey) in collaboration with The British Council (Ankara). Published: The British Council, ISBN 975-448-162-8.

Petrucci, M. [2001b] 'Poetry in Performance: Intertextuality, Intra-textuality, Poeclectics', in: *The Politics of Presence: Re-reading the Writing Subject in 'Live' and Electronic Performance, Theatre and Film Poetry*; the 3rd Research Colloquium held at the Research Centre for Modern and Contemporary Poetry, Oxford Brookes University, 2-3 April 2001 (main ideas first presented at the NAWE Conference on Re-Writing, 25 Nov. 2000, Oxford Brookes University) [retrieved from the World Wide Web: 1 January 2009 at www.mariopetrucci.com/otherwork.htm].

Petrucci, M. (2001c) *Schrödinger's Cat (The Bringing in of Creativity – Dead or Alive?),* Acumen 41, pp.14-18; also in: English Subject Centre Newsletter, issue 2, pp.10-12.

Petrucci, M. [2005] *Mission Possible: The Study Skills Pack* [retrieved from the World Wide Web: 1 January 2009 at www.rlf.org.uk/fellowshipscheme/writing/mission_possible.cfm] (available to download in pdf form; includes *The 13 Ways*).

Petrucci, M. [2007] *Creative Writing ↔ Science* [retrieved from the World Wide Web: 1 January 2009 at www.writeideas.org.uk/creativescience/].

Petrucci, M. (2008) *Creative Writing ↔ Science (Creative Writing through Scientific Ideas),* Writing in Education 45, pp.i-xii.

Pope, R. (1995) *Textual Intervention: Critical and Creative Strategies for Literary Studies,* London: Routledge.

Pope, R. (2002) *The English Studies Book* (2nd edn.), London: Routledge.

Pope, R. (2005) *Creativity: Theory, History, Practice;* London: Routledge.

Selden, R. & Widdowson, P. (1993) *A Reader's Guide to Contemporary Literary Theory* (3rd edn.), New York: Harvester Wheatsheaf.

Sorensen, V. [2004] *The Contribution of the Artist to Scientific Visualization* [retrieved from the World Wide Web: 10 September 2004 (and 1 January 2009) at http://visualmusic.org/text/scivi1.html].

The Shorter Oxford English Dictionary (1973) Oxford: OUP (1987 edition).

The Concise Oxford Dictionary, tenth edition (1999) Oxford: OUP.

Wall, A. & Tudor Jones, G. (2006) *Extremities of Perception*, in: Leonardo (J. of the Int. Soc. for the Arts, Sciences and Technology) 39 (5), pp.467-468.

Mario Petrucci holds a PhD in optoelectronics, degrees in physics and ecology, and has been a Royal Literary Fund Fellow at Oxford Brookes and Westminster Universities. He lectures widely on a variety of educational and literary subjects for such organisations as the Wellcome Foundation, the Institute of Education (University of London) and the Imperial War Museum, where he carved a small slice of literary history by becoming its first poet in residence (as he did in 2004 at BBC Radio 3). His recent ideas on siting poetry in public/ visual contexts include *LiterARTure*, while his Poeclectic approach is featured in the 2nd edition of *The English Studies Book* (Rob Pope, Routledge, 2002). Practical examples are given in: Petrucci, M. 'Public Poems: Performance Poems without the Performer?', NAWE Higher Education Forum (archived at www.NAWE.co.uk), *The Creative Writing in Higher Education Journal*, issue 2, Autumn 2001; also, Petrucci, M. 'Anaesthesia or Synaesthesia?', *Public Art Journal* 1 (2), October 1999, pp.15-17. For more on Poeclectics, *LiterARTure* or the author's other work:

www.mariopetrucci.com

Academic Summary

Any visual analogy opens, arguably, a porthole on the infinite 'whole' of intellectual discourse. Given that conventional text-based reasoning represents only part of the picture in cognition and education, visual analogies could help to galvanise important new modes of creative-critical teaching across the disciplines. The type of analogy emphasised here derives from observable phenomena in technology and science. A spectrum analogy for Intertextuality is introduced, developed later into a filter analogy casting a particular light on translation. Further examples include reception processes framed in terms of genetics, crosstalk and chaos theory. These attractive scientific forms, offered in a spirit of serious play, are very much a work in progress; but, once consolidated, the hope is that they will prime the more ambitious enterprise of extending the approach into many fields of study. With students increasingly attuned to visual input, and tertiary education involved in the modular degree, visual analogy not only contributes a fascinating and pertinent tool for exploring fresh learning interfaces between disparate subjects, but also carries the potential to ignite deeply participatory discussions within literary studies.

Note. This academic version of the paper gives an in-depth assessment of its ideas and principles. For a more straightforward take on the subject, one that concentrates more squarely on the application of visual analogies in classroom and seminar, see the other (user-friendly) version.