

# Context and text in scientific disciplines of English

## A social semiotic perspective

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As major world languages – Chinese, Spanish and Portuguese, for instance – become the medium of university networks, it may be the right time to take stock of the influence that English has had over the way the disciplines of humanities and sciences have been shaped, directed and evaluated, in particular in the second half of the 20th century. This paper is an attempt to understand some of the textual, linguistic and historical determinants of Disciplinary English (DE) specifically in the spectrum of technical subjects. DE is now a way of meaning which has become associated with objective authority. From this association, DE has shaped our disciplinary knowledge and spread across to registers of bureaucratic and political subject matter. The discussion also considers innovative potential in disciplinary discourses, in particular what Halliday regarded as the “knight’s move” in text: this is the related, analogical effect of Hasan’s “symbolic articulation” in verbal art and grammatical metaphor in the language of technical disciplines.

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### 1. Configurations of meanings for specific cultural tasks

Scientific activities, in particular from the 17th century on, have shaped the developing forms of English, but in the first place were themselves shaped by the social and cultural conditions under which knowledge was extended and valued. This reciprocation of text and context was explored by Halliday as a form of consistent “drift” in English (2004 [1988]:143–158). Other systemic functional linguists have elaborated this relationship in the form of disciplinary patterns of expression in Europe. For instance, Banks has set out the linguistic evidence

quantitatively in monographs concerned with the features of scientific language (2008) and with the origin of the register of technical journals in England and France from the year 1665 (2017). Significantly, Banks also argues in historical detail for direct lines of determination between the evolving construction of texture and aspects of the cultural contexts within which the linguistic developments emerged (see e.g. Banks 2017:17–44).

Systemic functional linguists have also focussed on the development of DE in the distinct institutional forms of the humanities, including in school discipline of English studies and literature (e.g. Christie; Rothery; Macken-Horarik: see a sample of references in Appendix 2; also Huisman: this volume). But this domain will not be included here. The patterns and tendencies of scientific ways of explaining events have been adopted in many cultural activities, namely, those in which speakers and writers have wished to draw on the “authoritative” effects of scientific patterns of discourse, or on what we have come to call technical registers (even in sports commentary!). This broader front of DE may be studied by examining other volumes in the collected works of Halliday and of Hasan (see discussion below), and by moving on to works by their colleagues (e.g. Halliday & Matthiessen 1999, 2014; Halliday & Martin 1993; Martin & Veel 1998).

My concern here is with the English that shaped the technical disciplines for measuring and managing the physical world, including the management of business and trade (see Crosby 1996 for the implications of measurement from ballistics to book keeping). Since one needs to characterise this reciprocation between the novel aspects of social situation, on the one hand, and the range of functions or discriminations made in textual meaning, on the other, one has to consider particular grammatical and semantic opportunities provided by English: for example, its considerable “machinery” for complex nouns, or “thing-ification”. The approach here is a “social semiotic” perspective: it takes the social order and the symbolic order to be mutually defining.

The dependency between the linguistic forms of science and the drift of English has intensified with the dominance of American and British cultural influence over university programs after WWII. It should be noted that the written form of academic exchange across Europe into Newton’s life (1642–1727) was another “lingua franca” – Latin (Grant 1996; Ostler 2007). Newton wrote monumental works in both Latin and English. The public service post held by the second most important poet in English – John Milton (1608–1674) – was the “Secretary for Foreign Tongues”, which required him to reply to diplomatic letters and debates from Europe through Latin (especially in the aftermath of the regicide of Charles I in 1649). Ultimately, English has taken over from Latin, and from the earlier influence of French and of German, as the means by which disciplines of empirical study are fashioned and distributed internationally.

In 2017, with over 20,000 universities and colleges of higher learning across the world, there may be a shift to other languages of publication – for example, Chinese and Spanish. There is now an opportunity to consider how new social contexts of enquiry and the responding forms of evolving English have shaped the forms that disciplines have taken, both in relation to university curricula and to schooling. The social semiotic investigation is not primarily concerned with the invention of novel lexis in sciences and disciplinary thinking (even though the terminologies of “subjects” certainly provide evidence of lexical novelty, as exemplified below). The fundamental issue is how resources of English that may have even long existed in popular speech have been elaborated to meet the key semantic drives of technical modernity, namely:

- a. objectification;
- b. quantification or measurement;
- c. the identification of sameness and difference;
- d. attribution and the “isolation of variables”; and
- e. the metaphorisation of reasoning into model building (a kind of imaginative or “as if” method). (See the 13 lexicogrammatical steps set out in Halliday 2004 [1988]: 141–142).

This essay will be mainly concerned with (e) above – it is the most difficult linguistic process to understand and evaluate, and it casts the widest net of influence since all of (a) to (d) can be found within the semantic consequences of (e). But along with these ideational or “world building” parameters, other systems from Halliday’s textual metafunction are central to the motivations for the characteristics (a) to (e). For example, as emphasised by Halliday as well as by numerous researchers (including Banks in his diachronic surveys), Theme-Rheme considerations are the main resource for maintaining a topical or semantic preoccupation, for expressing the thread of textual “unfolding” (what Halliday refers to as *logogenesis*, or the time of the text). In disciplinary discourses the theme often needs to be a distillation of much of what has been accounted for in the preceding text: as an explanation proceeds, the explainer needs to refer to what has been brought out in the preceding steps of the argument. This referring can only be performed by having a nominal expression – a notional “thing” or even a block of information which can be placed in the Theme and Subject roles of the clause expressing the next step. The linearity of experiential argument becomes a demand on textual “threads”, particularly the threads of cohesion: reference and cohesive conjunction. The Theme has to capture the process of text to that point, much as disciplines are ways of capturing the processes of our complex world in a series of “frozen” states (most typically, in the form of nominal groups of varying complexity). It is for this reason that the philosopher Alfred N. Whitehead (1865–1947)

drew attention to the “misplaced concreteness” of the subject-predicate grammar of English (emphasised by Waddington 1977 for biology; and by Butt 2008a in relation to systemic functional linguistics or SFL for short).

Halliday emphasises that there are 3 temporal perspectives on a text: there is the perspective from the history of the culture (phylogenesis); from the history of the individual (ontogenesis); and in relation to the time of dealing with the text as a sequence of expressions and interpretations (logogenesis). Sorting out the logogenetic unfolding of an explanation of a complex process is a key to why the grammar is put through the 13 “reshufflings” of grammatical role that Halliday referred to as grammatical metaphor.

## 2. Textual motivations for the “favoured form” of verbal science: A logogenetic perspective

The pressures motivating the developments in verbal science came from new contexts of social transaction and interpersonal relation. In verbal arts, new contexts are implicit in the work through the latent regularities in the grammar, choices that even the writers themselves are unlikely to monitor consciously. In this way, we sense a world redrawn, with human apprehensions set to different parameters: our symbolic contract with meanings coming back to us for re-negotiation.

Our concern here will not be, however, with that re-opening of the symbolic contract with which the artist appears to be pre-occupied. There is a connection in this between verbal science and verbal arts; but such a connection will be part of future attempts to work with ideas that Halliday raised but could not complete in his last years. My priority is with the drift in registers that contribute to contemporary university disciplines in science. Below, there are brief samples that offer some immediate sense of the lexicogrammatical motifs set out in detail by Halliday in *The language of science* (2004: volume 5 of *The collected works of M.A.K. Halliday*). To elaborate these examples, I have included, in the appendices, 5 pages from Professor Halliday’s own handout when explaining the re-allocations or shifts of function in the grammar that characterise “grammatical metaphor” (see Appendix 1 and discussion later in this paper).

To better understand the relevant textual motivations, we can begin from an instance of scientific explanation that illustrates problems of motion and forces as they might have been set out in the concrete sense of Aristotelian thinking (Aristotle 384–322 BCE). The approach is here explained by the historian of sciences, Stephen Toulmin:

[Aristotle produced explanation] by considering examples of a standard type or paradigm...If you want to understand the motion of a body...you should think of it as a horse and cart: i.e. you should look for two factors – the external agency (the horse) keeping the body (the cart) in motion, and the resistances (the roughness of the road and the friction of the cart)...

(Toulmin 1961: 52)

Toulmin notes that this is not “force” varies as “weight” times “speed”; and certainly not  $F \propto W \times V$ , which would be an anachronistic use of formulaic conventions that were not adopted until close to 1600 in Europe.

Following this is an instance of the language that Newton applied to describe a geometric problem, part of his description of “fluents” and fluxions – the capture of rates of change by mathematical means. This we now know through Leibniz’s term: calculus. (Readers need to note that the English of Newton’s *The method of fluxions and infinite series* uses a spelling convention of an extended “S” or  $\int$  for “s” in lower case):

#### SOLUTION OF CASE I.

18. Suppose the flowing Quantity, which alone is contain'd in the Equation, to be the Correlate, and the Equation being accordingly dispos'd, (that is, by making on one side to be only the Ratio of the Fluxion of the other to the Fluxion of this, and on the other side to be the Value of this Ratio in simple Terms,) multiply the Value of the Ratio of the Fluxions by the Correlate Quantity, then divide each of its Terms by the number of Dimensions with which that Quantity is there affected, and what arises will be equivalent to the other flowing Quantity.

Toulmin points out that Newton takes as his paradigm of mechanics a body that is no longer drawn from “everyday affairs” but is conceptualised in an “imaginary, idealized, state” that one would never actually meet in nature. But by adopting this abstract strategy, a whole architecture of connected representations and tractable steps (e.g. drawing a parabola and a line at a tangent to the curve of the parabola), Newton was able to create a new “intelligible order of Nature” (Toulmin 1961: 55–56), linking and solving many different and otherwise mysterious circumstances.

Here, next, is a sample of a widely distributed journal from the *American Association for the Advancement of Science*, 2016–2017: a report on “Potent peptide fusion inhibitors of influenza virus” science.org 27 Oct. 2017 vol. 358 issue 6263: 496.

Extensive data from virus neutralization assays, AlphaLISA assays, SPR, TS assays, X-ray crystallography, and in vitro and in vivo stability studies, as well as their lack of cytotoxicity, provide validation that these peptide fusion inhibitors have potential to translate into the clinic.

While we see the development of new words and the aggregation of acronyms as shorthand for the trained, this written sentence offers some signs of the intensification of grammatical variables across scientific discourse. The extracted sentence on an influenza virus is not just an overt example of the accumulation of technical terms – many factors need unpacking. For example,

The nominal group “extensive data [ | | | | | ...cytotoxicity]” is an agentive expression, namely it is “these data [...]” which “provide” and so the nominal group realizes grammatical Subject, and Actor, and Theme in the clause. Human involvement is not as relevant in this symbolically constructed world. We are in what Karl Popper called World 3 – a construction of the objects of our thoughts (Popper 1972). We are in a domain with a non-material field, and the relations between elements involve quasi necessity, quasi agency, and a logic that needs to run parallel to, while not being dependent on, the logic of explanations of common sense (viz. the “horse and cart” paradigms). The Newtonian problem of “action at a distance” (i.e. gravity holding giant bodies flying through empty space around the sun) is now intensified in today’s science by quantum theory and “spooky action at a distance” – Einstein’s claim of the incompleteness of quantum theory due to the now confirmed “entangled” nature of information between distant electrons (Gilder 2008; Whitaker 2006).

The term “validation” as a nominal makes the process vague (who validates? under what conditions?) It is presupposed that you know how validation in this field happens.

The expression “these peptide fusion inhibitors” is a nominal group in which a number of different processes are condensed. These require pre-knowledge from the culture and/or the preceding text. This nominal group is then given an abstract property – a “potential” – that is to translate (themselves?) “into the clinic”. The definite article here is an abstract, homophoric reference: “You know what I mean by clinic” – i.e. it is not a specific clinic but the generic homophoric, like “the farmer is having a difficult season for crops”; the “the” stands for all farmers.

The clause is built up as: || Extensive data [ | | | | | ] provide validation [ [ that...have potential [ [ to translate [into the clinic]] ] ].

By tracing the cultural patterns that contributed to such textual “drift” in English, we can come to a linguistic interpretation of how our contemporary disciplines have evolved and how they have directed the form of current university studies. Consider the following summarising extract from *Current biology* (2017) on how countershading and stripes in the theropod dinosaur *Sinosauropteryx* reveal heterogeneous habitats in the early cretaceous Jehol biota: by Smithwick, Nicholls, Cuthill and Vinther. The authors wrote:

A clear darker dorsum and absence of pigmented plumage ventrally, with the light ventral side extending to the tail until at least the tenth caudal vertebra, conforms to what would be expected for countershaded camouflage adapted to reduce detection from visual predators and from potential prey.

Smitwick et al. (2017): 3339

To render the expert's specificity of anatomical statement, there is again the unusual Verbal Process: "conforms to (what would be expected...)", and the down-ranked processes: countershaded; adapted; reduce; detection (and even predate and prey upon?). From the characterisation of the ways in which the disciplines have been communicated linguistically, we need also to consider the increasingly dominant role of other semiotic tools for representing theories of human experience – for instance, the emphasis on images, diagrams, graphs of measurement and iconic modelling. Hence we will need to develop a social semi-otic theory (following Kress & van Leeuwen 1990; O'Toole 2011 [1994]) which encompasses those metaphoric forms which extend linguistic meanings: especially certain mathematical, iconic and theoretical fictions which are tools of explanation (e.g. "limit" and "infinitesimals" in calculus; the Feynman diagrams in physics). As pointed out sarcastically by Bishop Berkeley (1734), in response to the work of Newton and Leibniz, the fictions involved in the new science, including gravity's "action at a distance" (i.e. holding giant bodies in their orbits in the heavens, for example), were harder to believe than any claims of *the New Testament Bible*. Furthermore, much of the same semantic assumption in (1–4) above might also be illustrated from the insider, technical talk between bureaucrats, and even today in the commentary on sports. The modes of verbal science have been caricatured and passed across to other registers in which speakers and writers seek the authoritative tenor of sciences, especially through a patina of precision and the aura of inexorable truths (note, for instance, the "in group" effect of using acronyms and standardised terms: see Klemperer (2002 [1957]) on the way abbreviations and other forms were used in "nazi-speak" to signal inclusion, and exclusion, along with formulations which were like "tiny doses of arsenic" in the takeover of quotidian activities).

In a number of publications, Halliday tabulates the movement between grammatical functions in 13 steps; but first, in explaining the process in class, he typically offered a number of illustrations of agnate, or systemically related clauses.

The issues to be noted here are:

- i. decoupling of the level of semantics (element, figure, sequence) from the lexicogrammar;
- ii. dislocation and reallocation of grammatical roles due to the heuristic or virtual "objects" of science;

- iii. the anaphoric pressure (logogenetic pressure) of carrying what has been argued into the forward moves of argument or demonstration;
- iv. increasing lexical density;
- v. cause and effect in natural processes reconstrued as token and value relations in the clause.

### 3. Phylogenetic and contextual perspectives

One way to dramatise our social semiotic considerations of DE is to set out from what seems to be a simple question: how did we get from there – the first definite European developments of “disciplines” in sciences and arts – to here (where we are today in our academic activities)?

Any claims of historical and cultural origins can produce a lifetime of argument; but the majority of discussions based on European intellectual history focus on the 17th century as the nascent era of modern science, the “watershed” period when the learning of Copernicus, Kepler and Galileo passes over to Newton (born in the year that Galileo died), to Leibniz and to the new Royal Society in London, with members like Boyle and Hooke. In the literature of the early 17th century, we see the new science influencing John Donne (his imagery rather than his topoi or themes), and John Milton, a poet, scholar and influential civil servant. Milton, for example, is blending his prodigious classical learning with face-to-face conversations with academicians across Western Europe, including Galileo. The language of enquiry and for the expression of ideas is moving from Latin to vernacular languages – Italian, French, English and German – and the first journal-like publications are appearing and being used to announce findings (as well as to monitor thought in France: see Banks 2017). This is by contrast to the epistolary exchanges (or just plain secrecy) of previous eras.

### 4. Context of culture

It is both surprising and unnerving to consider the transformation of the institutions of knowledge in Europe over the “brief” period from 1650 to today. The power of Classical Greek science can leave one with the belief that science formed early in Western culture, and progressed steadily on a broad front over 2500 years. The “natural philosophy” of Aristotle (c. 380 B.C.E.), his less cited observations on marine life, for example, certainly appear to keep company with the habits of observation which Darwin exhibits in the 19 books which he wrote, including on molluscs. But this idea of even progress may be a false impression. The writings



of Geoffrey E.R. Lloyd (e.g. 2002) and of Stephen Toulmin (1961), in particular, do bring out the continuities and integrity of what people of learning achieved before the modern era: the “ambitions of curiosity”, as Lloyd surveys them. When one can follow the changes across contributing cultures, including Arabic, Indian and Chinese centres of learning, the continuity of human effort may appear insistent (especially see Lloyd 2002; and the monumental works on Chinese science by Joseph Needham 1900–1995).

But let us consider what is involved in our sense of a European “modern era” and in the development of sciences and universities after the work of Copernicus and of Galileo, after the new vision of the place of humans in a universal order. The work by Dolnick, *The clockwork universe: Isaac Newton, the Royal Society, and the birth of the modern world* (2011), brings us “down to earth”, with its opening chapters on the social milieu of western European cities like London and Paris. London in 1650 was overwhelmingly the capital of rotting refuse, disease and the superstitious readings of a world constantly interpreted as the signs of God’s impending retribution. The giants of European “science” as we call it today – Kepler, Newton, Leibniz, for example – still saw their main work in extracting meanings that were coded cryptically in the various forms of *the Bible* and then in the material order behind God’s plan. Mathematics was the chief instrument in the service of uncovering God’s plan. Truth was settled. Newton, like most scholars, believed that there had been a golden age in the past, and that the change in the world was an indication of decay – an immoral miasma which, they believed, would soon be brought to an end by God. Many regarded the year 1666 as a likely year for God’s judgement as it was associated with the devil’s number “hidden” in *the Bible*.

This is not our sense of a modern era. As Dolnick points out, the plague of 1665 and the fire of London in 1666 heightened the sense of cultural malaise (see Defoe’s writing 1722). City living killed more people than it bred. Plague visited every few decades, killing and bewildering great swathes of the people who had no theory of hygiene, let alone knowledge of germs. The “heavens” were “read” for signs of God’s impending “doom” (judgement), not for cosmic understanding (Dolnick reminds us that “disaster” came from dis-“astra”: Latin for “star”). Crucial here is the idea of decoding – decoding the hidden cyphers of the wisdom of God’s earliest age of perfect knowledge and creation, as if in a pre-fallen era. In this sense, all of what we call the root of modernity in science was not regarded as discovery, but as a form of uncovering (or recovery) of wisdom previously and perfectly understood by the great worthies of the past, a past encrypted in *the Bible* and in the works of some other exalted authorities. In his lucid quantitative and diachronic studies, Banks (e.g. 2017) emphasises the contrastive conditions of France and England during the 17th century: France under Louis XIV consolidating the divine right of monarchs and the order of the Catholic church, along with a policy of monitoring

ideas; England searching for a settlement after the Civil War to reconcile monarchy with parliamentary oversight. An interesting point of common ground may be the fate of learning under absolutist thinking and social control (Louis XIV and Cromwell); an interesting note in relation to sciences and learning of today is the support of learned societies by monarchs and their representatives. By appointing directors it was expected that one might control what was discussed.

Let us return to the question: how did we leave behind this unrecognisable milieu, this period that is regarded as the “watershed” period in the development of forms of new knowledge, yet seeming so alien to our own values of progress, evidence and principles of enquiry? The question could be sharpened by asking: how did we get our contemporary, institutionally shaped disciplines – astronomy, medicine, mathematics, physics, chemistry, grammar, logic, rhetoric – from the superstitious practices of astrology: sacred numbers, alchemy, theology, and pre-occupations with satanism or witchcraft? The nub of these issues might be foregrounded by the question: why did these cultural changes happen so fast?

## 5. Contexts of situation

With some reflections on the contrasts across cultural time, it is now practical to invoke Halliday’s 3 variables of context of situation: field (the character of the event), tenor (the interpersonal relations) and mode (the meaning to channel relation).

In dealing with social context to meanings, one needs to propose variables that bring out salient differences between social settings – that is, differences that have consequences for the meaning, just as the conditions themselves are a product of the opportunities for meaning that the language differences create. This is to say that meanings “are” the context when viewed from language, and the meanings “realize” the context when viewed from society. This is the bilateral dependency of context and text, which we can consider as points on a cline of instantiation (hence, both on the same stratum, but looking two ways, or Janus faced) or as realization (if one treats the context as having a structure realized in system, homologically with the structure of clause).

Problems raised concerning systemic treatments of context include:

- a. what are the systemic options? (in demotic idiom we might say: where do they come from?);
- b. how are they motivated? (a version of (a) above);
- c. how are they compared for descriptive efficacy? (an implication of (b) above);

- d. how do the systemic treatments of context relate to the terms register (semantic variety), text type and the spectrum of current uses of the word genre?
- e. how are coding orientation or semantic variation of participants (e.g. Hasan 2009 [1989]: 180–231) to be managed, namely as differences of instantiation in the same context, as different points of view on the same context (taking each participant as a reference in a social topography), or as constituting a different context altogether for each social “position”?

Here, a few remarks on (a–d) might assist in evaluating what follows.

Saussure (2011[1906–1911]) proposed a view of language based on the complex consequences of layers of differences. A related view of human information was put forward by Bateson: humans have to attend to differences that make a difference (1979:99). In the study of grammatical systems in the West, scholars have “turned language back on itself” (Firth 1957 [1950]:181; Halliday 2002 [1988]), typically taking common terms and moving them into philosophy, rhetoric, grammar and logic (e.g. Greek – *telos*: finally; *meta*: beyond; *syntaxis/syntagma*: arrangement(s); *paradigm*...and so on; Latin – *sub iectus*; *ob iacio*; *ablative*: all variants of location turned to grammatical roles). There is nothing sacrosanct or ontological about these proposals. They were a boon to the progress in teaching Greek and Latin languages throughout the period from Aristotle up to even the time of Milton who, as mentioned above, conducted government diplomacy in Latin and direct conversation with scholars in Italy (Beer 2008:Chapter 6).

Since the contexts of immediate classical influence, it might be claimed that these terms have functioned both as a beneficial benchmark and as a distorting drag on progress in the depiction of relationships across the languages of the world, suggesting as they do a kind of biased expectation as to an underlying pattern in grammars.

There are many historical and pedagogical reasons why communities and scholars have not proposed and refined a similar working “term bank” for a level of linguistic context. One reason appears to be that such a framework was developed and generalised – the 2500 year study of rhetoric or oratory. But, despite being based on functions (*ethos*; *pathos*; *logos*) and on generic moves or structures (e.g. *exordium*; *narration*; *division*; *proof*; *refutation*; *peroration*), and despite having a proto-stratal organisation (with tropes and arguments as semantics and schemes as lexicogrammar), rhetoric has been relegated to the “trivial” (related to the three branches of study, the *trivium*: rhetoric, grammar and logic). Since Shakespeare’s era, there is evidence that these subjects were inflicted on students through odious teaching methods and that they were used as instruments of class-based education. This is illustrated in the early portrayal of Mr. Gradgrind in *Hard times* by Charles Dickens.

It is important, however, in a theory of meaning that the contextual level of description should “pull its weight” in the description of linguistic behaviour. The task is to propose and trial variables (differences) which “make a difference”, and to organise them around the differential networks of Halliday’s systemic linguistics (Halliday 1973; see also the socially adaptive networks of Lamb’s earlier conventions in stratificational linguistics based on Halliday’s initiative, e.g. Lamb 1984). The results can be surprising, even if they need to be built up register by register. One finds, for instance, how the roles of pilots and surgeons differ and are similar in non-obvious ways, throwing light on why these two professions combine for conferences on safety (and why the participants sometimes end up baffled by the attitude of the other profession: personal communication, John Cartmill, the Australian School of Advanced Medicine).

What follows was developed in the light produced by Ruqaiya Hasan’s attempts, over 4 decades, to bring the description of context to a level of efficacy that could be considered “industrial strength” (a criterion often cited in personal conversation by Christian Matthiessen). Hasan’s work trialled many forms of proposal, and her work can be, and should be, pursued in considerable detail (as volume 4 of her *Collected works*). The discussion below draws on a small selection of differential categories – a very small selection taken from work applied by myself and colleagues (Moore, Wegener, Tuckwell, Hoadley, Khoo, Lukin and Cartmill). Much of what I have proposed was criticised by Hasan from a number of points of view. A case in point, which bears out Hasan’s rigorous approach to theory, is her criticism of my use of her own earlier field distinctions based on the term “goal orientation”. In the 1990’s, Hasan rejected the use of “goal” since it invoked arbitrary and subjective judgements (viz. intentions), it confounded forward looking purpose with backward looking knowledge of the textual outcome and it reduced the interpretation of the total context to a single dimension of description. My response is the emphasis of “orientation”: whether an event was punctiliar or durative, whether it involved iteration(s) (like the long and the short term goal orientation of educating your children) and whether the orientation was implicit or explicit in the terms that the community used with regard to the iterative layers of actions and meanings (Hasan 1999: 234–237).

Before she died, Hasan introduced some radical changes to her own networks. She appeared to be seeking a theory that would suffice in the protean character of experience: one that distinguished the “setting off” from the “trajectory”, and these from the “final outcome” of the context. In my view, Hasan had already demonstrated how to dimensionalise context so that complexity could be managed. She kept to her overall aim: a level of description that cut down the “context free” or informal approach in much linguistic theorising, and that reduced any need for the universalistic assumptions of some logical and psychological

approaches in pragmatics. The message in summary is: look for differences in the context “that make a difference” (to echo Bateson) and see if they group into degrees of relatedness that suggest a system of systems (see Butt 2008b).

Context networks can be regarded as pragmatic in the sense discussed in relation to William James (1842–1910) and Charles S. Peirce (1839–1914), namely, that of efficacy in relation to a problem. The efficacy of a network is the main criterion for the science of bringing context to bear on cultural description. One can ask: “[w]hat is the potential of the network as a whole for assisting practitioners in anticipating change, and in better managing the “work” in a specific context?” A singular, redundancy-free network seems to me an unnecessary step into idealism. It may be an instructive heuristic ideal for research, however. It certainly was for Hasan.

It is relevant to reflect here that natural, evolving systems are themselves an aggregation of anomalous and/or redundant vestiges of evolutionary ancestry of living forms (viz. the vulnerable human knee and our ancestry with fish in the sea). It may be of little or no cost to the “tool power” of meta-descriptions that they be applied without critical concern for economy in a theory. Furthermore, in evolution, dormant systems can re-emerge with new relevance under new conditions of context. The combinations in eukaryotic forms of bacteria suggest that “life” pays little attention to Ockam’s razor. There may also be a benefit arising from retaining descriptions, as in the case, for instance, of “face-to-face” options in tenor or mode: they may now be recombined with systems of “at a distance” and “delayed” messages as a result of recent interactive options on mobile phones (viz. video messaging and skype). So, too, the emergence of systems that do not combine can be a valuable discovery: there may be a logical block between options; or it might be a semantic “blind spot” in the culture – potential that the culture has not taken up.

In recent years, support in adopting pragmatism (in the Jamesian sense above) comes from the emphases of Deacon’s treatment of levels of scientific description and the effects of interdependent teleodynamic systems (see e.g. Deacon 2012: *Incomplete nature*). Deacon illustrates the scientific approach to degrees of order in the universe in terms of limiting degrees of freedom viz. eliminating possible combinations of molecules or of events. This approach puts the emphasis on eliminating certain directions in the account of complex order, rather than seeking the essence of “things”. Here too, Deacon emphasises the aptness of Bateson’s formulation: “differences which make a difference”. As with Saussure’s notion of “valeur”, significance is achieved not by defining an essence to a phenomenon, but by determining the alternatives that are ruled out, or “in absentia”. This emphasis will need to be elaborated or contested in future work on contextual parameters, as well as evaluated through writing Hasan completed just before she became extremely

ill. Such work includes a 100 page manuscript, close to completion and originally destined for Chapter 8 of the *Collected works*, vol.4. In this manuscript, Hasan emphasises a long tradition of predecessors who have contributed to the analysis of context. Beside names already mentioned in this article, Hasan includes Ellis, Mitchell, Berg, Ure, Gregory, Greaves, Benson, Cummings, as well as Hymes, Gumperz, Goffman and Bernstein. In the present discussion, the concern has been with treating context as systems of differences that can be represented as networks; consequently, it has been organised around Hasan's initiatives and their connection to Halliday's text to context linguistics.

### 5.1 Field

Let us consider here domains like the "sphere of activity"; "the role of material action"; "actions with symbols"; "goal orientation" (all of which were systems developed or trialled by Hasan in her classes in the 1980's).

For "sphere of activity", e.g. "specialised" or "quotidian" (viz. a relevant probe is: did you need special training to participate?):

In the C17th: most activities of enquiry were subordinate to uncovering the divine order behind the chaos and mutability of the fallen, imperfect, earthly domain. Knowledge was to be retrieved from an earlier era of wisdom (certainly the view of Newton). This kept many writers secretive, more akin to the notion that they had unlocked a secret of nature – something in their keeping. Experimental activities were a blend of "freak show" for entertaining the spectators and a raising of important findings (for instance, the paper to the Royal Society by Newton showing that white light contained the rainbow spectrum of colours was a minor event in terms of impact, though hugely important to our historical perspective). Upper class membership dominated the entrants to the Society (which required a fee, Banks 2017: 32). Robert Boyle, the head of the Royal Society, was extraordinarily rich and in need of no patronage. On the continent, the wealthy Tycho Brahe showed through his private observatory that doing "natural philosophy" was beginning to involve technology (telescopes, sextants) that would demand patronage or centralised bureaucratic support (much as the development of guns/ballistics was increasing the need for a regimented nation state). Right up to the era of Darwin in the C19th, the freedom that wealth bestows was an important ingredient to research (hence the time and interactions Darwin was able to devote to his 19 books). Science needed and has continued to rely upon personal wealth or institutional support: Gregor Mendel was part of a research tradition in a religious order (which gave him opportunity to conduct experiments: see Lewontin 2000: Chapter 3). Note that the field of science in China was different to the field of classical Greek theorists. Chinese astronomers, for example, were

bureaucrats on Imperial patronage: their critical roles included being able to predict signs in the heavens (i.e. comets and any sign that could be read as a threat to the “mandate of heaven”: see Lloyd 2002: 33–35).

Field in the C20th: specialisation after 1900 meant that no-one could know all there is to know even about one discipline (the biologist, Steve Jones reflected on whether the poet John Milton was the last man to “know everything... [Now] there are no Miltons even of biology”; 2000: xxvii–xxix). Entry to a field is conditional on a specialist degree (PhD), with the goal of investigating topics set down by a laboratory in an institute, with a constitution and an annual budget. The experimental work is directed to recognised problems, and funding is typically passed on by competitive grants or industry support. Science is subordinate to the source of funding. One does not directly exercise choice in doing science.

This apparent development has many narrowing and deleterious effects on innovation. Some of these are highlighted in *Free radicals: the secret anarchy of science* (Brooks 2011): how scientists need to pursue conventional topics to gain funding; how progress can be hijacked by ruthless heads of laboratories; how peer review can reject new thinking; and how it is often the topic that will make money that decides the research direction, not the scientific significance (e.g. consider the under explored effectiveness of lithium in mental health sciences, since no one can patent it).

## 5.2 Material action

C17th: the material actions of scientists might be regarded as undergoing extreme shift in this period – mainly through the new authority accorded to experiments with natural objects and those involving humans (like blood transfusions with animals!). “Natural philosophers” had to meet the challenge of demonstrations and data (especially concerning “heavenly bodies – e.g. the records kept by Tycho Brahe). Galileo’s turning of the telescope on the moon and the moons of Jupiter, and the world revealed by the microscope, encouraged new contexts of empirical observation.

C20th: the material actions of scientists and of scholars more generally have become diverse: there are laboratory techniques that bring the human in close to processes and there are the distances involved in radio telescopes and particle colliders (with which the scientist is interpreting instrumental “readings”). Anthropology is beginning as a discipline with Boas and Malinowski bringing the observer “down off the verandah” and into learning the language. Evidence is now taken from every material domain, and scholars must be equipped for the material stratum aligned with their sub-specialisation. Some become famous for a material find (the skeleton of 3.5 million year old “Lucy”), and others for their possibly

unrealizable “thought experiments” (the physicist John Bell and Bell Inequalities, see the Davies and Brown interview of Bell (1993 [1986]); Gilder 2008 for a narrative account, or Whitaker 2006 for a lucid, more technical explanation).

### 5.3 Action with symbols

C17th: one deciphered from the hidden encryptions of God, either in God’s words or in God’s works in nature. Novelty or innovation was considered lack of faith, even morally reprehensible, as it smacked of a craven curiosity (not a virtue).

As they moved into naming and generalizing about experience, disciplinary thinkers in English (as in other languages of Europe) have been able to draw upon the classical resources of both Greek and Latin. This classical repository for cladistics (i.e. for hierarchical taxonomic mapping of things, types, and species (Hoenigswald & Wiener 1987)) has provided a platform for relatively unified European intellectual disciplines since then, through the Mediaeval role of Latin (an intellectual “lingua franca” or common speech between the learned from the Roman Era up to the end of the 17th century). Greek and Latin terms were systemised and legitimitised by theological practice.

Halliday notes (2004 [1998]:e.g. 67 & 94) that, for the most abstract ideas, Greek terms have typically been applied in disciplines or knowledge structures. Greek terms have usually been prior to Latin both historically and in terms of abstraction and the status of the author (viz. Aristotle). Latin has supplied the contexts for the codification and rhetorical defence of the classical world-view, albeit in the domain and sponsorship of the Latin church (Grant 1996; 2007). A crucial figure of speech in these contexts for church scholars was the announcement, in introducing debate, that the scholar was speaking either “naturally” or “theologically”. New cosmological ideas could be debated if the scholar was speaking naturally, and the church was in this way an agent of science, not always the enemy as popularly caricatured.

C20th: innovation is an undisputed virtue and goal, as is curiosity. There is an assumption that first to publish “owns” the idea (viz. Fleming is credited with the “discovery” of penicillin but it was actually developed by Florey and his team during WWII). Publications become an aggregation of academic merit (secrecy now protects patents or businesses or weaponry: God is not the main audience or witness as was the case for Newton). Science is primarily concerned with understanding change (reconstructing evolution, the development of cancer cells; changing electron orbits). This was a contrast with the pursuit of eternal qualities and objects in an unchanging, ideal dimension behind the world of human perceptions (see the metaphysics of Pythagoras and of Plato; the links between measure, musical modes and emotions; and the role of ideal forms of which the world



instantiates in only rough approximations). Crucial categories in science are now theorised as “fuzzy”: harmony, order and infinite complexity co-exist in debates over whether the cosmos exhibits deep properties with numerical characteristics defying randomness (e.g. Kauffman’s work as in Deacon 2012:170–171). With the work of Boltzmann in 1895, measurements of sub-atomic phenomena and entropy became statistical, not particularising and absolute. So many of the topics that scientists debate today involve what linguists might describe as the irrealis (see Kappagoda 2004): the construction of an imaginary domain that artificially models conditions one might infer from the “messy” facts of experience. It is interesting to note too that Heisenberg’s speech at the 500th anniversary of the birth of Copernicus (“Tradition in science”; 1973) referred directly to a new role for symmetry from Platonic ideas. We could conclude that the tension between the pursuit of universalising principles and an inchoate material cosmos goes on in science, and the perpetual renewal of “order” remains a mystery, as ever, even if the depiction of order can be exemplified in new astonishing and challenging details each year (see Deacon on teleodynamic systems; 2012:357–367).

#### 5.4 “Goal orientation”: short or long term goals; or both; with or without explicit declaration or evidence of the ultimate goals

C17th: the “natural philosopher” was an extension of theological traditions and training with the long-term goal of extending the demonstration of God’s perfection; the shorter-term goal may have been personal religious salvation; but Newton’s work was “addressed” to religious ends. Other personal motivations are not discounted here, but the institutionalised character of knowledge activities as we might call them, is the main point. The fact that both Newton and Leibniz for 20 years “sat on” their separate extraordinary discovery for managing change and motion (fluxions, or the calculus) indicates the difference between the contemporary race for “innovation” and the secretive goal of a natural philosopher of the 17th century.

C20th: while ownership of an idea was not just a recent development (viz. the bitterest of disputes between Newton and Leibniz over who was first with calculus), the goal orientations of modern disciplines and their academic leaders involve us in a complex set of inferences. We might start this process of inference by noting the significance in the C20th of Nobel prizes; patents in technology and pharmacology; entrepreneurial teams (the race for the human genome); university pressures on funded research; and the milieu of capitalist competition. A comparison with the system of monastic support around the work of Mendel (on genetic inheritance in beans: Lewontin 2000: Chapter 3) is a contrast from which a historical discussion would be an absorbing development.

## 5.5 Tenor

Let us consider here, in a cursory review, the role of differences for “social hierarchy” (e.g. relations dictated by law, or custom, or expertise or institutional experience); “social distance” (the regularity and character of one’s exchanges); “agentive role” (whether you act in an office with designated responsibilities); and “network ‘morphology’” (here the point is whether or not your place in the speech fellowship is part of a dense multiplex network or a uniplex, individuated branching).

In many ways, the tenor within scientific communities offers the most surprising challenges to generalising about the contexts of disciplined thinking and activity in science. The conventional stereotypes of selfless, isolated geniuses, like Curie or even Einstein, do not stand up to closer examination: the importance of face-to-face exchanges is in evidence in the work of the figures of the Royal Society; in the life of Darwin; in the quantum debates of the C20th (like the Solvay conferences); in the work on DNA (the team headed by Maurice Wilkins). The study by Brooks (2011) also brings out much of the ruthless and risk-taking behaviour that scientists have exhibited. On the other hand, the quiet progress of a thoughtful individual is also exemplified (for instance, the ground breaking and Nobel prize winning work of Barbara McClintock in cytogenetics: her work progressed because it was at first dismissed, and she was left undisturbed to experiment with her maize crops; Shapiro 2011).

What then, we need to ask, are the differences that help us to probe the context of culture and immediate contexts of research pertaining to the development of the disciplines of research science? The tenor network might involve some 100 interdependent contrasts. Only the directions of enquiry have been outlined here. The contrasts (or the “loss of degrees of freedom” from Deacon 2012:192) range over: (1) whether there is a hierarchy in the relations, and whether the terms of work are non-discretionary; (2) whether agentive roles are specific or shared between all in a similar manner, and whether any office is determined by extrinsic status; (3) whether the participants share backgrounds of training, familial and social connections, recurrent contacts through existent local or other shared commitments – religion, musical training, clubs and activities that promote a codal sharing of values. One might then wish to rate the degree of these connections and relate them to group or dyadic relations.

By pursuing these lines of difference, it is possible to bring out the range of variations between eras and between individual experiences as scientists. For instance, among all the “jumble” one deep similarity amongst innovative researchers is, whether by accident or design, they were able to exercise their ideas in an interlude of unusual freedom (sometimes by being overlooked, sometimes by being outsiders, and also, in many cases, after achieving a reputation in another

field: for instance, the way Gerard Edelman turned from his Nobel prize winning work in immunology to applying his cellular Darwinism to neurons (Edelman & Tononi 2000: 79ff).

## 5.6 Mode

Differences between the C17th and the C20th in mode are also stark. These can here only be suggested in outline, not fully set out in networks. But the differences are grouped around: is the language “constitutive or ancillary” to experimental and other semiotic forms? Is the communication “face to face”? Is it a “shared and reciprocating” process? Are responses “delayed or immediate” in debates and communication? Is the channel “written or spoken, and congruent” (i.e. written to be read individually, and spoken to be heard)? So too are there strictures placed on communication by conventions of “generic forms”: private letters, journal reports, popular explanations, specialist, peer-reviewed articles, government reports etc. All these suggest new social contexts for sciences, with the constant semantic pressure of convincing and persuading both peers and non-specialists.

If we make a modest network in each of the parametric domains – field, tenor and mode – it turns out that the modesty covers for a great deal of complexity. So, approximately 100 combinations in each network (a quickly achieved number) produces around 1,000,000 differences that make a difference to the expression of meaning.

## 6. The ontogenetic perspective: the early roots of disciplinary discourse from home to school and to university

Let us now reflect on the life of the individual – ontogenetic development and the roots of disciplinary discourse. We can ask how educational knowledge begins in the development of the child through discourse with (a) the mother; (b) guidance from the teacher of primary school topics; (c) how the patterns of talk spiral up in the teaching of subjects by specialist teachers at “high” school, and (d) how they take on a new purpose at university level. As in Halliday’s approach to the three times of text – the phylogenetic, the ontogenetic, and the time a text takes, or the logogenetic – we can bring the problems of English across scientific disciplines into clearer view by working closer to the grammatical facts of developmental, or ontogenetic, change. So, let us consider the vector of semantic pressure over the life of a person “graduating” from home and kindergarten ultimately to the talk of universities.

You may be surprised, as I have been, to observe how early it is that certain mothers (perhaps most) bring their children into quasi “formal” operations or emphatically linear arguments. Some followers of Chomsky’s views on universal grammar have claimed that mothers “correct for truth not for grammaticality”, and that this “renders mildly paradoxical the fact that” children emerge grammatically competent but not necessarily truthful (Brown et al. 1968). Looking back at the heyday of innatist views of syntax in America, such a diminution of the discourse and role of mothers brings little credit to linguistics. Mothers might be described, empirically, as speaking to prepare their children for the world as they, the parents, have experienced it or believe it to be. Mothers highlight necessary discriminations for dealing with experience and the potential for understanding the processes around people and ideas and feelings within people. Consider the three step (or quasi-syllogistic) reasoning in the following incidental exchange (these data from a project by Hasan on semantic variation: *Volumes 1 and 2 of the collected works of Ruqaiya Hasan*, including a CD of samples of data and their analysis; see in particular the report by Hasan & Cloran 1990, now Chapter 3 of Volume 2; see also Williams 2001):

*Child: Oh. Oh. (Complaining about stirring onions in cooking with mum).*

*Mother: I know you don't like onions*

*But I always put them in corn bread (A)*

*And you always like cornbread. (B)*

*So I don't think you really mind. (C)*

The simple form here is: A and B therefore C.

Even more of a challenge is exemplified by the child’s riposte to her mother here – the mother has tried to turn about the child’s wish to stay away from kindergarten, the child (4 years 9 months) is saying that she hates everything about school. The mother mentions the teacher, knowing that the girl loves her teacher. The child uses an inverted syllogism in her reply:

*M: Do you hate Mrs McDonald?*

*C: Do I hate my family?!!*

*I'd hate you if I hated her.*

*Do you hear that?*

*'Cause I love her.*

*Do you hear that?*

*I'd have to hate you!*

Already the necessity of logical or causal consistency is employed for rhetorical effect – the concluding: “I’d have to...” Reasoning has become a “force” in the

interpersonal sphere (a socio-semantic “pressure” like atmospheric pressure acting on our biological being).

For a child (4;0 years) in another context, the mother’s mode of advising the child is through a range of modal expressions which enhance the sense of a methodical enquiry: “you often call people a goose if...”; “you know if...I say”; “and sometimes you can say...”; and “I think you’d say...”. This all concerns when you can call a person a “goose” or a “fussy hen”: no scientific discipline at issue, it would seem. Yet the modal range brings in what you do usually in the community: what the child herself may have heard the mother say; what is sometimes appropriate; and what the mother personally “thinks” would be the case in a hypothetical situation proposed by the child. For this child, the world is not being presented by fiat – in unequivocal categories. The child is being offered a manner of establishing the spectrum of cultural practice, or meaning at stake, in what Hasan emphasises: simply “the living of life”. Vygotsky observes how the great novelist, Tolstoy, saw the difficulties in teaching young children word meanings that did not pertain to the immediate living of life, the word “impression” for example (Vygotsky 1962: 83). Vygotsky suggests a contrast with teaching a foreign language, in which routines may have a productive role. Learning an abstract word in one’s own language requires the “general linguistic context” as support. The mother, in the text above, is orienting the child to a particular self-consciousness about how one comes to know anything at all. In building on the work of Bernstein, Hasan managed to produce quantitative evidence of how such “coding orientations” vary in family homes in Australia, and how the school system recognises and rewards codes differentially (e.g. Hasan 2011: Chapter 5).

When the mother orients the child to “notice” the grammatical options, it may be a first move in bringing a new, higher, conscious control over choice in language. This may be analogous to that new consciousness we get to exercise when we pass through the formal school training to write, and need to hold a self-directed line of thinking (see Vygotsky 1962: 98–101: “[t]he child learns to do consciously, what he has been doing unconsciously in speaking”).

Other transcripts demonstrate the early pedagogical strategy of formalising names – the specifics of “casualty department” in a hospital; the way rectangles share some features, but “the name we’re are going to give it [a shape held up] is an oblong”. But we need to ask: what is going on behind the vast front of individual home and primary school exchanges? What seems to be the motivating principles behind the way that language is orienting the development in children?

The drift of learning as taught to this stage in childhood (in the Sydney suburban community) may be characterised as follows:

- α: that we need to relinquish expectation that the world can be understood by information from the senses alone, and
- β: that we must attend to the primary role of symbols – the world as interlocking representations of the world.

Reasoning through symbols takes over from other forms of knowing.

In the following brief episode between 5 year old children, reasons overrule observations when one of the little recording packs the children are wearing fails (there is no pink light indicating that the battery is “on”). One child realises that there is a problem with his battery: but the other children go to extremes of reasoning to explain that it is just the power of the sunlight which prevents the light being seen. The child replies that, no, it was not showing inside the classroom either. The kids dismiss this by saying that the classroom is just not dark enough to show the light. They are wrong in their stance, but rationalise their way to an erroneous conclusion, a conclusion that their own sensory experience of the classroom should have precluded (Butt 2004).

*Child 1: Aah! (into microphone).*

*Doesn't work.*

*Ch 2: Yes, it does.*

*They just put another battery in.*

*Ch 3: That's for*

*Ch 1: Oh...the light's on.*

*Ch 3: No...it*

*When you cover it up*

*It goes pink;*

*But when you go like that...[?...] ]*

*Ch 4: Yeah, because of the sun.*

*Ch2: Cas...cas...I'll show you something.*

*Ch3: No it was like that inside (to Child 4).*

*Ch1: Is yours the same?*

*Ch3: Yeah.*

*Ch5: But when it's dark*

*When it's dark*

*It's red.*

*...Pink, I mean.*

*Look.*

*Ch2: Show ye something?*

*Ch?: What?*

*Ch3: But it was like that inside.*

*Ch4: Yeah, because...because...inside.  
It's not dark inside.*

I am suggesting that the base or foundation to disciplinary thinking begins early. It involves committing to symbolic representations and their increasingly elaborate interdependency. High school in Australia (now 13 to 18 years) is concerned with the specialised architectures of distinct subjects, all presenting varieties of disciplinary representations for managing experience. Examples with shared underlying principles include the graphing in mathematics using Cartesian axes; the way maps can be drawn and scaled for different purposes in geography (e.g. Mercators or Peters projections; and for topographic or political detail); and perspective in art.

At another level, our higher-order thinking brings such separate disciplinary activities out into an understanding of shared, or similar, semiotic principles. In each of the apparently core activities of these three separate disciplines, there is the common problem of representing the dimensions of the world of experience on the 2 dimensional surface of graphs, maps or paintings. With Cartesian axes one can move on to represent change and acceleration (by bringing a tangent line to the curve of a parabola in differential calculus). In topographic maps, the lines are understood to represent equidistant points in the world: so close lines on the map “must” mean that the terrain is very steep – the points are vertically distant from each other. Perspective is another tool by which a simulacrum of the world is fabricated so that distance is represented as consistent with an artificial depth towards a vanishing point. The result of understanding number systems over and above the decimal system (to use an example from Vygotsky 1962:115) is to produce a new freedom of operation. This is because the choices are understood as different modes of achieving the same end result, or of achieving an outcome with slight but perhaps significant advantages. Greater degrees of semiotic comparison for undertaking such operations of meaning are an important aspect of higher institutions of learning (Hasan 2005 [1992]: Chapter 3; Kellogg 2017)

## **7. Disciplined imagination: from analogy to meaning potential**

The roots of disciplinary forms – naming, generalisation (including measurement) – in early child and school developments suggest that we need to consider what is the significance of Halliday’s notion of grammatical metaphor, but in the light of what Halliday came to call “the knight’s move” (after the swerving options

of the knight in the game of chess). This swerve was for Halliday a way of thinking about the move into abstraction. But, he emphasised, abstraction needs to be distinguished from a narrower notion – that of being just “abstract”. Something “abstract” is without a realization in sensory or experiential report: it has no, or only a tenuous, connection to empirical evidence. But what, you may ask, is the difference with Halliday’s use of abstraction? The response here is empirical motivation – there has to be a link to realization in the material order. In this sense, Halliday’s “abstraction” might be regarded as the complexification of the concrete. This might be further described as an attempt to address phenomena, in particular social phenomena, closer to their actual contexts. We then need to ask: why the “knight’s move”? why is it two steps up and a step sideways? The answer here might be best offered in two forms: (a) by reflecting on the character of major scientific innovations; and (b) by considering the difficulties that practitioners and theorists have had in characterising what is essential to science. Here we are limited to using some of the major innovations of science to offer a suggestion as to what Halliday was characterising.

Darwin’s great imaginative leap was to envisage the origin of life as a slow diversification of populations of beings (species), beings marginally better equipped to deal with changing patterns of geographic conditions, especially the periodic isolations and expansions of suitable niches in habitation. Darwin used the ideas of Malthus to underpin the central tenet of evolution: “natural selection” or “descent with modification” (Darwin 1998 [1859]:642). This inspired imaginative step across fields of thought led to the idea of a common origin to living forms. This inversion of conventional thinking emerged from a cross disciplinary leap, as well as observations from the everyday “wisdom” of pigeon and dog breeders (who try to “design” animal breeds: Darwin 1998 [1859]:Chapter 1). The prod to Darwin’s thinking “is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdoms; for in this case there can be no artificial increase of food, and no prudential restraint from marriage” (1998 [1859]:91). Alfred Wallace, the cofounder of natural selection was equally motivated into his leap of imagination by reading the population study of Malthus. It is significant that Malthus’s data were in fact misleading, as they were based on the unusual situation of the United States and its westward expansion of European settler communities. We have a good example then of how a concept, while inappropriate in one developing discipline, nevertheless engenders an imaginative and crucial transformation in another. Darwin and Wallace, through their related observations of forests, mountains and the “umvelt” of various living forms, had to turn the biosphere “upside down”: with a primordial, uncomprehending form creating what we regard as species through gradual change – something in direct opposition to any theistic view of an intelligent being bestowing the essence of each



species into the world. We have a step across, and then steps forward in human thinking: a knight's move. We have moved from a totally abstract domain which offered humans little opportunity to elaborate (creation by a transcendent being) to another idea, one in which nature is "made strange" (to use a concept from Russian literary criticism), but in which there are many concrete ways of following up the abstraction of evolution with consistent, empirical, measurable techniques.

So, it is relevant to reflect on other crossovers between the sub-disciplines that have become modern science. In 1943–1934, one of the three main theorists of quantum physics, Ernst Schrödinger, gave a series of lectures on the quest: *What is life?* (published 1944). He took his particle physics from the discipline of physics over to biology. This move assisted the transformation of life sciences into molecular and genetic microbiology. It created a novel confrontation with deep problems: viz. how order persists by passing on order; and how order develops in the face of entropy (nature's tendency to disorder: the standard problem of the Second Law of Thermodynamics). It was a creative cross-disciplinary move – a transposition of the rigours of one form of explanation to another one – with suggestive analogies about code or script, a repetitive, "aperiodic crystal" (ultimately a gene); and the analogy between quantum leaps and genetic mutation.

In our contemporary academic world, in the focus on the brain and mind, we have Nobel prize winning scientists coming from biology over to neuroscience – for example, Francis Crick (originally trained as a physicist, before finding the structure of DNA with James Watson), and Gerald Edelman, who researched chemistry and immunology. Edelman, mentioned already above, carried over the population thinking (the "Darwinism") that he applied in his earlier research to the study of neurons in human brains – hence "Neural Darwinism". We can summarise this by saying that a move sideways is often an analogy that takes on the appearance of a homology: a similarity can be pursued as if it were actually based on a shared underlying principle of life or of material forms (see Edelman 1992, 2006).

Following the work of Halliday, we can envisage language as a crucial agent of change: we see a form of language gradually creating or guiding a new range of contexts. One might equally say that these contexts were themselves demanding a new language. This language had to bring out the seeds of potential in the natural ways that academics came to talk about experience – for instance, reflect here on both the benefits and the "costs" of the nominalising power of English grammar (Whorf 1956) and its "tight" referential tracking (by contrast with Chinese, for example, La Polla (personal communication)).

To give agency to aspects of language may seem to overstate the phenomenon. But nothing can be known without being realized semiotically, without being captured for oneself and for others in the nets of expression. Such "nets" manifest the dependencies between people and "things" under actual conditions of living.

From the point of view of linguistics, whatever the limitations of revolutionary ideas in scientific thinking – whether in relation to the work of Darwin, or Einstein, or other titanic figures – still, a noteworthy key to progress appears to have been face-to-face talk. Darwin knew most of the leading naturalists and geologists of England – they questioned each other directly. Einstein and Bohr, and other leading figures like Heisenberg, met informally for walks and at crucial small forums (e.g. Bacciagaluppi & Valentini 2009). Recall the fact that John Milton travelled to speak with scholars across Western Europe (claiming to have met with Galileo). Perhaps, despite all the crafts of written and digital modes, we should not devalue, in our research or in our teaching, the roots of mental catalysis in clear steps of real time talk!

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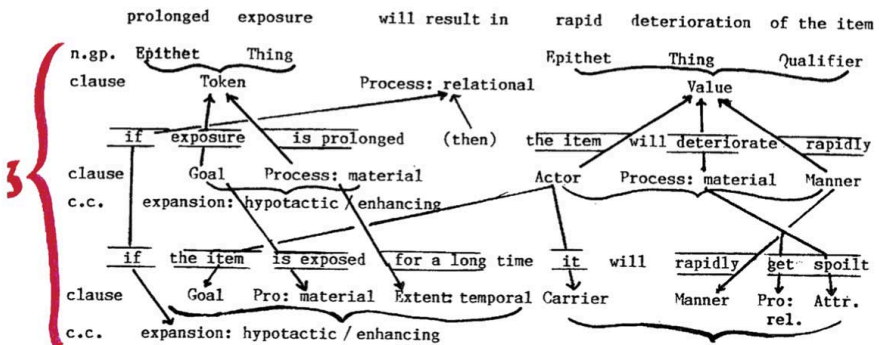
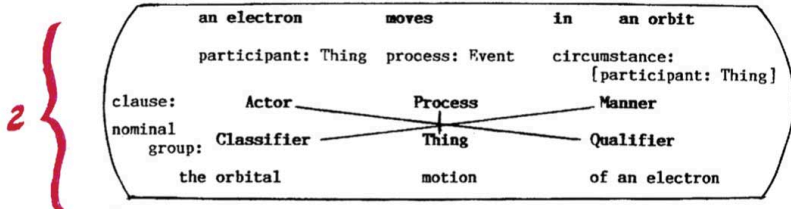
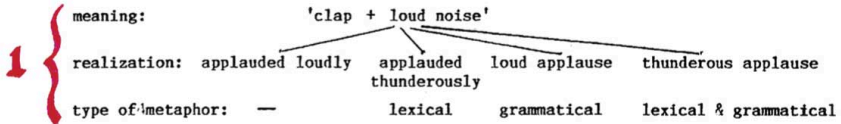
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## Appendix 1. Handout by Michael A.K. Halliday, as typed

MAKH © 25-29

On metaphor in grammar [Language as Social Semiotic IV]

\*  
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glass cracks more quickly the harder you press on it  
 cracks in glass grow faster the more pressure is put on  
 glass crack growth is faster if greater stress is applied  
 the rate of glass crack growth depends on the magnitude of the applied stress  
 glass crack growth rate is associated with applied stress magnitude

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'thing a undergoes process b in manner c to the extent that in manner x  
 person w does action y to thing a'

'[complex] thing b-in-a acquires property d in manner c to the extent that  
 [abstract] thing xy has process z done to it'

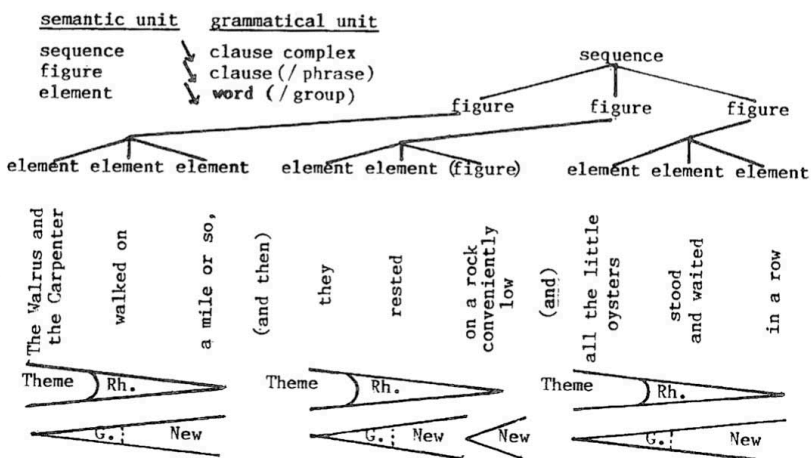
'[complex abstract] thing abd has attribute c under condition that  
 [abstract] thing xy has process z done to it'

'[complex:abstract] thing c-of-abd is caused by [complex abstract] thing  
x-of-zy'

'[complex abstract] thing abdc causes/is caused by [complex abstract]  
 thing zyx'

On metaphor in grammar [Language as Social Semiotic IV]

1. Semantic "rank scale", construed by congruence with units in the grammar:



2. Flux of experience and flow of discourse: ↗

3. An element (participant nominal group):

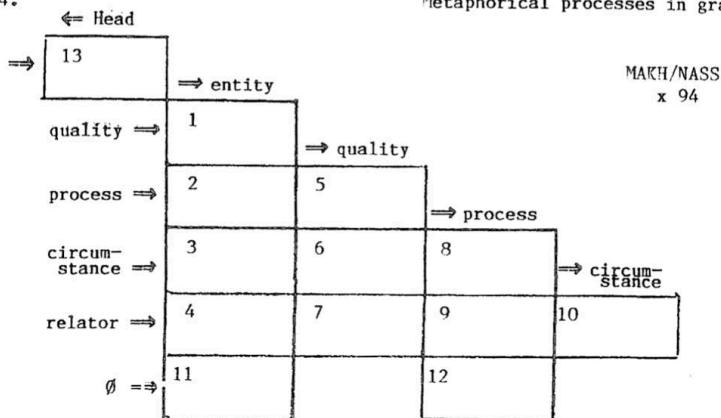
some portion of Australia's	last few	viable	tropical	rainforests
faceting	pointing out	ordering & counting	describing	classifying categorizing (entiaizing)
PreDeictic	Deictic	Numerative	Epithet	Classifier Thing [cpd.]

locating instantially	locating systemically
("impermanent / identifying")	("permanent / non-identifying")

- 4.

Metaphorical processes in grammar:

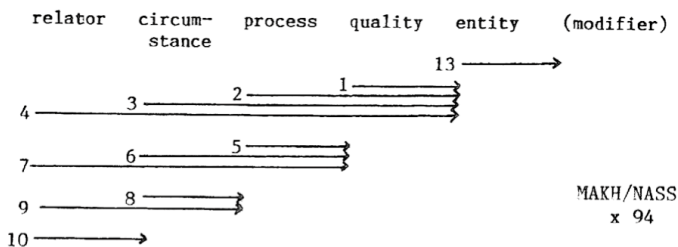


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5. Types of element, and congruence with grammatical word classes:

relator (in sequence)	minor process (in circumstance)	process	quality	entity
conjunction	preposition	verb	adjective	noun

6. The "general drift":



clause complex	clause	nominal group
----------------	--------	---------------

a happened; so x happened  
 { x happened because a happened  
     x happened as a result of happening a  
         happening a caused happening x  
             the resultant happening of x ...  
                 the cause of happening x ...

7. Typical "syndromes"  $(1+13+6; 2+13+6; [2]+9+[2])$ :

The slow growth of cracks corresponds to the sequential rupturing of

[6	2	13	(2)]	9	[6	2	13
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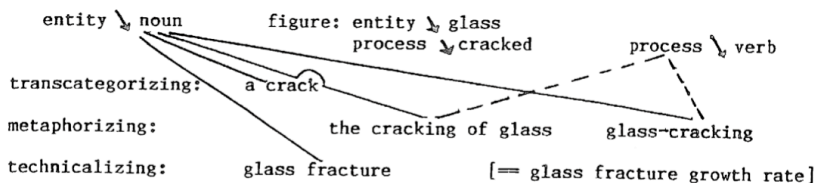
interatomic bonds at rates as low as one bond rupture per hour.

$$6 \quad (2) \quad 1 \quad [(2); E3 \quad 2]$$

Cracks grow slowly — as slowly as when the bonds between the atoms rupture one after another only once an hour.

(Glass cracks slowly — as slowly as when one atom stops being bonded to another atom only once every hour.)

8. Semogenic processes:





## On metaphor in grammar [Language as Social Semiotic IV]

13 shifts \*  
to metaphor 28MAKH/NASS  
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## Metaphoric processes in grammar

1. quality  $\Rightarrow$  entity                      adjective  $\Rightarrow$  noun  
Epithet = Thing                      unstable = instability
2. process  $\Rightarrow$  entity                      verb  $\Rightarrow$  noun  
(i) Event = Thing                      transform = transformation  
(ii) Auxiliary = Thing:  
    (tense)                      will / going to = prospect  
    (phase)                      try to = attempt  
    (modality)                      can./could = possibility, potential
3. circumstance  $\Rightarrow$  entity                      preposition  $\Rightarrow$  noun  
Minor Process = Thing                      with = accompaniment; to = destination
4. relator  $\Rightarrow$  entity                      conjunction  $\Rightarrow$  noun  
Conjunctive = Thing                      so = cause / proof; if = condition
5. process  $\Rightarrow$  quality                      verb  $\Rightarrow$  adjective  
(i) Event = Epithet                      [poverty] is increasing = increasing [poverty]  
(ii) Auxiliary = Thing:  
    (tense)                      was / used to = previous  
    (phase)                      begin to = initial  
    (modality)                      must / will [always] = constant
6. circumstance  $\Rightarrow$  quality                      adverb / prepositional phrase  $\Rightarrow$  adjective\*  
(i) Manner = Epithet                      [decided] hastily = hasty [decision]  
(ii) other = Epithet                      [argued] for a long time = lengthy [argument]  
(iii) other = Classifier                      [cracked] on the surface = surface [cracks]
7. relator  $\Rightarrow$  quality                      conjunction  $\Rightarrow$  adjective  
Conjunctive = Epithet                      then = subsequent; so = resulting
8. circumstance  $\Rightarrow$  process                      be / go + preposition  $\Rightarrow$  verb  
Minor Process = Process                      be about = concern; be instead of = replace
9. relator  $\Rightarrow$  process                      conjunction  $\Rightarrow$  verb  
Conjunctive = Event                      then = follow; so = cause; and = complement
10. relator  $\Rightarrow$  circumstance                      conjunction  $\Rightarrow$  preposition / -al group  
Conjunctive = Minor Process                      when = in times of / in ... times  
   if = under conditions of / under ... conditions
11. [zero]  $\Rightarrow$  entity                      = the phenomenon of ...
12. [zero]  $\Rightarrow$  process                      = ... occurs / ensues
13. entity  $\Rightarrow$  [expansion]                      noun  $\Rightarrow$  [various] (in env. 1, 2 above)  
Head = Modifier                      the government [decided] =  
   the government's [decision], [a / the decision]  
   of / by the government, [a] government(al) [decision]  
   the government [couldn't decide / was indecisive] =  
   the government's [indecision], [the indecision] of  
   the government, government(al) [indecision]

\*or noun; cf. mammal  
[cells] / mammalian  
[cells]

[from Michalske & Bunker, 'The fracturing of glass', Scientific American, December 1987]

Even though the fracture of glass can be a dramatic event, many failures are preceded by the slow extension of preexisting cracks. A good example of a slowly spreading crack is often found in the windshield of an automobile. The extension of a small crack, which may have started from the impact of a stone, can be followed day by day as the crack gradually propagates across the entire windshield. In other cases small, unnoticed surface cracks can grow during an incubation period and cause a catastrophic failure when they reach a critical size. Cracks in glass can grow at speeds of less than one trillionth of an inch per hour, and under these conditions the incubation period can span several years before the catastrophic failure is observed. On an atomic scale the slow growth of cracks corresponds to the sequential rupturing of interatomic bonds at rates as low as one bond rupture per hour. The wide range of rates over which glass can fracture — varying by 12 orders of magnitude (factors of 10) from the fastest shatter to the slowest creep — makes the investigation of crack growth a particularly engaging enterprise.

THE FRACTURING OF GLASS ... the mechanism by which glass cracks ... the stress needed to crack glass ... as a crack grows ... the crack has advanced ... make slow cracks grow ... the rate at which cracks grow ... the slow growth of cracks ... the rate of crack growth ... we can decrease the crack growth rate ... glass fracture growth rate

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[miscellaneous examples]

- 1 The atomic nucleus absorbs energy in quanta, or discrete units. Each absorption marks its transition to a state of higher energy.
- 2 Increased responsiveness may be reflected in feeding behaviour.
- 3 The growth of attachment between infant and mother signals the first step in the child's capacity to discriminate amongst people.
- 4 Strength was needed to meet driver safety requirements in the event of missile impact.
- 5 While either of these two variables was sufficient to produce a shift in the form recognition laterality pattern, combining both variables did not increase the magnitude of the shift.
- 6 Griffith's energy balance approach to strength and fracture also suggested the importance of surface chemistry in the mechanical behaviour of brittle materials.
- 7 The model rests on the localized gravitational attraction exerted by rapidly oscillating and extremely massive cloud loops of cosmic string.
- 8 This figure accords well with the seepage estimate of an equivalent drop in the reservoir level of  $4.2 \text{ mm day}^{-1}$ .
- 9 The goal of evolution is to optimize the mutual adaption of species.

## Appendix 2. A selection of references for the notion of DE studies – specifically for studies of literature and grammar in classrooms

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