

## Language change in scientific discourse

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**Abstract:** *Halliday has demonstrated that changes in discourse function co-vary with changes in the grammatical resources a language makes available to construe discourse.<sup>1</sup> Specifically, he outlined the ways in which nominalisation evolved as a resource for construing scientific reality as a world of logical relations among abstract entities. In the present article, Halliday's theory of the scientific text as process will be outlined. The founding principle of this theory, how grammatical metaphor has introduced changes in scientific English, will be illustrated through analysis of selected lexical items and semantic relations.*

**Keywords:** Scientific discourse, functional grammar, metaphor

**Section:** Article

## 1. Halliday's functional grammar and the language of science

According to Halliday, the language of science is “the various forms of discourse in which the activities of ‘doing science’ are carried out”.<sup>2</sup> His approach is through systemic functional grammar, which theorises “the grammar in such a way that it is possible to interpret texts as instantiations of a meaning-creating system and its sub-systems”.<sup>3</sup>

Halliday starts from two basic assumptions: the grammar of every natural language is a theory of human experience and an enactment of interpersonal relationships. These two functions of grammar, which he calls the ideational and the interpersonal, act together with another, the textual, which creates discourse.

What grammar does, therefore, is to transform human experience into meaning. In the most general terms, grammar construes experience as *process*, in the form of a *grammatical unit*, a *clause*. Each process is in turn construed as *configuration*, in the form of a grammatical structure. The components of a grammatical structure are a) the *process* itself; b) certain *entities* that participate in the process and c) various circumstantial elements associated with it and construed as *grammatical classes*. Then one process may be related to another, by means of *grammatical conjunctions*. Therefore, the way things are is the way grammar tells us that they are. However, we experience our perception of things when we become aware of some change taking place in our environment. Hence grammar construes experience around the category of process: a process typically represents some sort of change. However, to sort out a process of change from the entities that remain in existence throughout and despite the change, is an enterprise of semiotic construction.

What is significant is the fact that some processes which make it possible to construe experience, by transforming it into meaning, also provide the means with which to challenge the form of the construal. Once experience has been construed, it can also be reconstrued in a different light. Semiotic consciousness, however, not only depends on functional diversity, but also on stratal organisation; in other words, the ‘meaning space’ is both defined by metafunctions (ideational, interpersonal, and textual) and stratification. Language is a stratified system in which the content plane is split into a semantics, interfacing with the world of experience, and a lexicogrammar.<sup>4</sup> Meaning is thus created on two strata, with a relation of realisation between them: the semantic and the lexicogrammatical. The semiotic energy of the system comes from the lexicogrammar.

If we focus on the ideational function, we can represent the way experience is construed into meaning as outlined in **Table 1**:

**Table 1**

|                         | <i>SEMANTIC</i>  |                            | <i>LEXICOGRAMMATICAL</i>  |
|-------------------------|--|----------------------------|---|
| <i>Ranks</i>            | Sequence (of figures)<br>Figure<br>Elements (of figure)          | Realised by<br>”<br>”      | Clause complex<br>Clause<br>Group/phrase  |
| <i>Types of element</i> | Process<br>Participating entities<br>Circumstance<br><br>Relator | Realised by<br>”<br>”<br>” | Verbal group<br>Nominal group<br>Adverbial group or prepositional phrase<br><br>Conjunction |

Grammar, in a stratified system, sets up categories and relationships and has the power of ‘construing’ but it also can deconstrue along different lines. Since stratification involves mapping meaning into forms, ‘process’ into verbal and ‘participant’ into nominal - as in the clause *the boy is*

*running* -, it also allows remapping of ‘process’ into nominal form - *the boy’s running*. The clause has thus been reworded as a nominal group and the experience has undergone a process of metaphorisation.

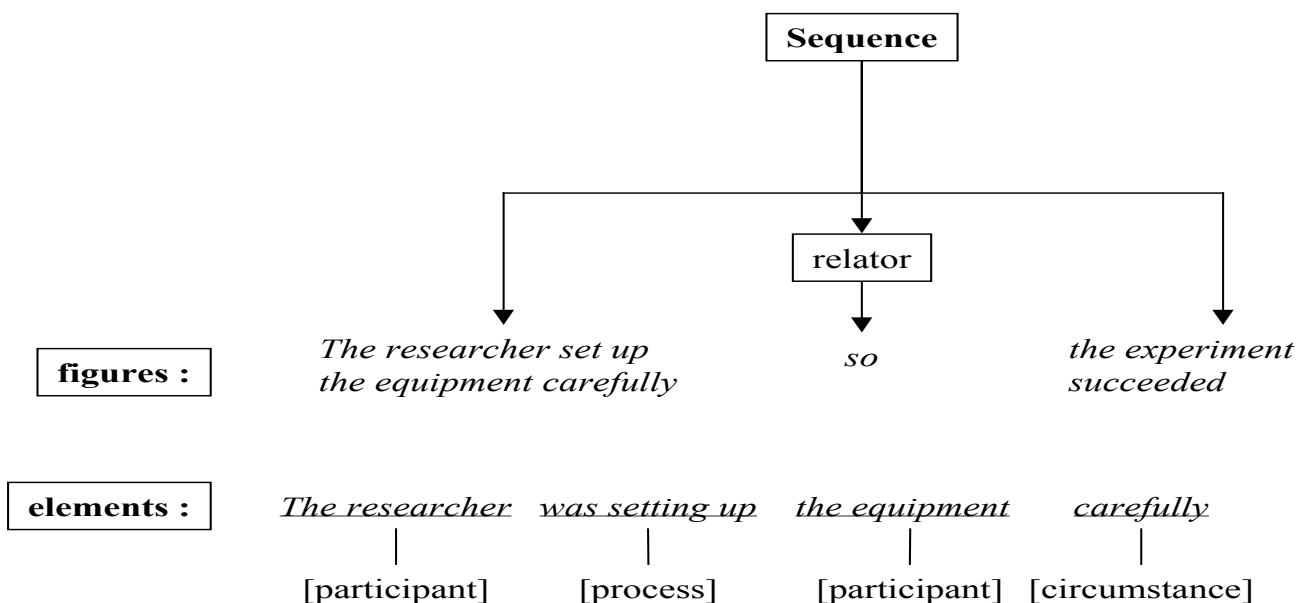
## 2. Grammatical metaphor in scientific English

Just as natural languages embody in their grammar a theory of experience, scientific language, as “a dedicated and partially designed semiotic sub-system”,<sup>5</sup> reconstrues certain aspects or components of human experience. However, in opening them up to be observed, investigated and explained, it does so in a different way. The problems addressed by modern theories in physical, chemical and biological sciences often involve phenomena that are far removed from the experiences of every day, like gravitational waves, catalytic reactions or the human genome. However, when we examine the grammatical patterns in which these theories are construed, it is clear that they evolved from the grammar of natural languages. I will illustrate this with an example. The following expression:

*the researcher set up the equipment carefully so the experiment succeeded,*

is a sequence of figures realised by a clause complex and it is diagrammatically represented as in the figure below:

Figure 1

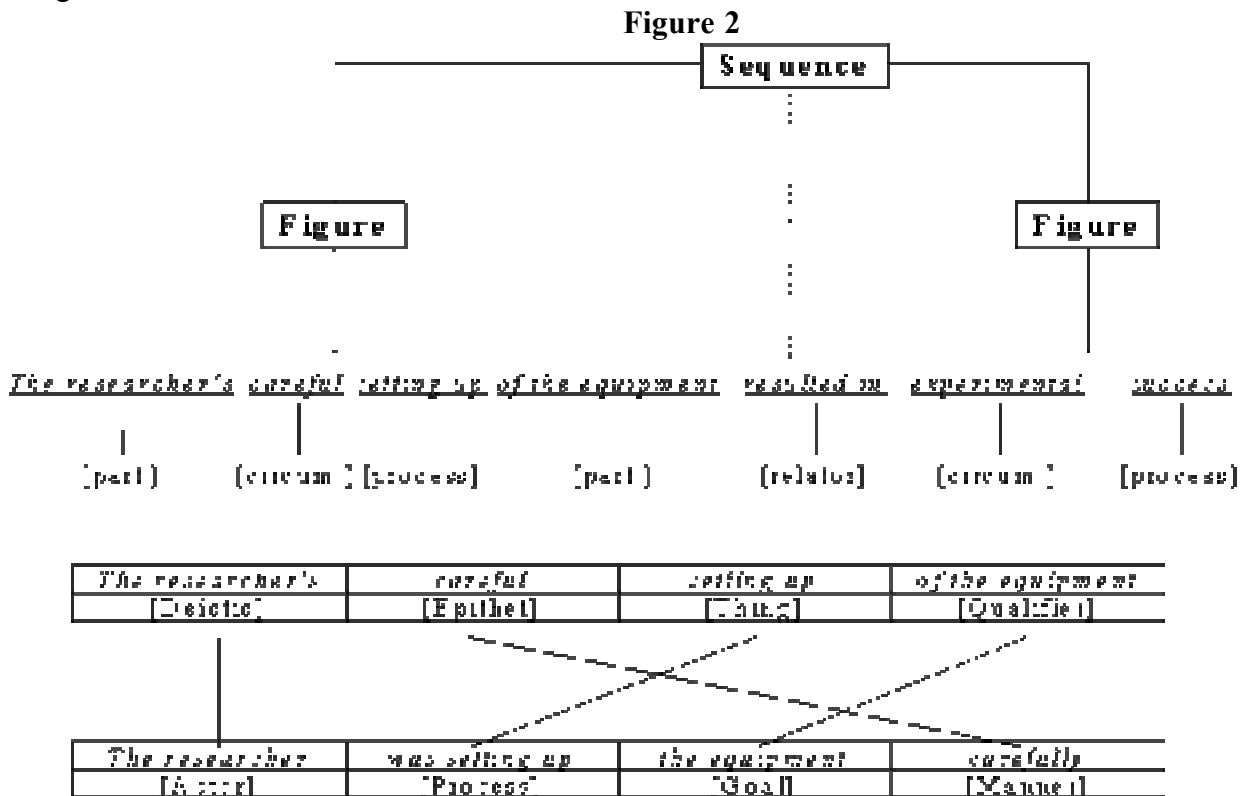


This clause complex may be gramatically transformed into:

*researcher’s careful setting up of the equipment resulted in experimental success.*

It is clear that between the two there is a highly complex relation of grammatical metaphor because a number of transformations have taken place simultaneously: *the researcher/the researcher’s*; *set up/setting up*; *the equipment/of the equipment*; *carefully/careful*; *succeed/success*;

*experiment/experimental; so/resulted in.* These transformations are represented diagrammatically, in the figure below:



It must be noted that the metaphorical shift involves two kinds of grammatical movement: one in rank, the other in structural configuration. On the one hand, there has been a movement down in rank:

- a) a (semantic) sequence, congruently<sup>6</sup> construed as a (grammatical) clause complex, is reconstrued as a (grammatical) clause, which congruently construes a (semantic figure);
- b) a figure, congruently construed as a clause, is reconstrued as a group, which congruently construes an element in the figure.

On the other hand, there has been a movement across in function/class: this is very complex since it involves:

- a) reconstruing each configuration as a whole ((i) - researcher + set up + carefully - from clause functioning as primary clause in paratactic clause nexus to nominal group; (ii)- experiment + succeed - from clause functioning as secondary clause in paratactic clause nexus to nominal group);
- b) reconstruing each individual element, from a function in the clause to a function in the nominal group ('researcher' from Actor in clause to Deictic in nominal group; 'set up' from Process in clause to Thing in nominal group; 'equipment' from Goal in clause to Qualifier in nominal group; 'carefully' from Manner in clause to Epithet in nominal group; 'experiment' from Actor in clause to Classifier in nominal group; 'succeed' from Process in clause to Thing in nominal group;<sup>7</sup>
- c) reconstruing the relator 'so' from Conjunctive in the configuration of the secondary clause to Process in the single remaining clause.

Thus grammatical metaphor is a realignment between a pair of strata: a remapping of the semantics on to the lexicogrammar. The example given above has been contrived on the model of the

favourite grammatical pattern in modern scientific English.<sup>8</sup> The examples analysed in the following sections are taken from a corpus of scientific articles on catalysis by gold, published between 1997 and 2001; and a text book on theoretical inorganic chemistry, published in 1962.

### 3. The ‘favourite clause type’ and types of grammatical metaphors in scientific English

According to Halliday, the ‘favourite clause type’ in English scientific writing can be characterised as follows:

*semantic level:*            **sequence of two figures, linked by a logical semantic relation**

*grammatical level:*

**[congruent] nexus of two clauses, with Relator/conjunction in secondary clause**

**[metaphoric] one clause, ‘relational: identifying/intensive, circumstantial or possessive’, of three elements:**

|                      |   |                     |   |                                  |
|----------------------|---|---------------------|---|----------------------------------|
| <b>Identified</b>    | + | <b>Process</b>      | + | <b>Identifier</b>                |
| <b>Nominal group</b> |   | <b>verbal group</b> |   | <b>Nominal group<sup>9</sup></b> |

Examples are:

- 1) *theoretical molecular orbital calculation indicates almost no possibility of O<sub>2</sub>- formation<sup>10</sup>*
- 2) *higher calcination temperature gives higher catalytic activity<sup>11</sup>*
- 3) *the adsorption of CO on the surfaces is one of the important steps in CO oxidation<sup>12,13</sup>*
- 4) *The activity of the catalysts apparently rose with increasing particle dimension<sup>14</sup>*
- 5) *Complete washing to remove Na and Cl causes the propylaldehyde formation<sup>15</sup>*
- 6) *An increase in water concentration gave rise to small increases in the conversion of nitrogen<sup>16</sup>*
- 7) *Reduction of nitric oxide on gold catalysts is enhanced by the presence of both oxygen and water<sup>17</sup>*
- 8) *The immobilising time and efficiency depends on the concentration of gold<sup>18,19</sup>*
- 9) *The reaction involves interaction of CO with surface hydroxyl groups<sup>20</sup>*
- 10) *Alternative uses for natural gas include conversion to value added chemicals and liquid fuels<sup>21,22</sup>*

There are also variant forms with ‘relational’ processes in the *attributive* mode, where the second nominal group may have adjective as Head, like in *The catalytic activity of Au/TiO<sub>2</sub> for CO*

oxidation is largely dependent on the nature of Au-titania interaction,<sup>23</sup> or with relational existential process with one nominal group only, like in *No dissociation of oxygen occurs*.<sup>24</sup>

It must be pointed out that these favourite clause types are not the most frequent but are the most critical, in the semantic load that they carry in developing scientific argument.<sup>25</sup> What is rather interesting about them is that their clause structure is very simple: one nominal group plus one verbal group plus a second nominal group or a prepositional phrase. But packed into this structure there may be a very high density of lexical matter. In fact, if we unpack these clauses, we note that they have gone very often through more than one cycle of metaphoric transformation; and the most plausible congruent rewarding will have two, three or even more clauses in it, as shown in the example:

- 11) *Simultaneous transformations of both gold and support precursors during temperature-programmed calcination provoked the formation of Au catalysts highly active for the low-temperature CO oxidation*<sup>26</sup>

(When precursors of gold and supports are calcined in conditions of temperature programming, they are simultaneously transformed so that highly active catalysts of Au are formed on which CO oxidises at low temperature)

(Because precursors of gold and supports are simultaneously transformed when they are calcined in conditions of temperature programming, highly active catalysts of Au are formed on which CO oxidises at low temperature)

It is clear that a great deal more is happening at the rank of word than simply construing processes and qualities as entities. As we have noted before, the grammatical metaphor involves a complex move down in rank and across in function. However, we first need to illustrate the possible range of metaphoric shift from semantic function to grammatical class.

Starting from the congruent pattern of clauses, some of the metaphoric shifts which may be found in scientific discourse are listed in **Table 2**:

**Table 2**

| <i>Shift in semantic type</i> |                             | <i>Shift in grammatical class</i>     |                             |
|-------------------------------|-----------------------------|---------------------------------------|-----------------------------|
| <i>Congruent</i>              | <i>metaphorical</i>         | <i>Congruent</i>                      | <i>metaphorical</i>         |
| <b>1. quality</b>             | <b>entity</b>               | <b>Adjective</b>                      | <b>noun</b>                 |
| <b>2. process</b>             | <b>entity</b>               | <b>Verb</b>                           | <b>noun</b>                 |
| <b>3. process</b>             | <b>quality</b>              | <b>Verb</b>                           | <b>adjective</b>            |
| <b>4. circumstance</b>        | <b>quality [manner]</b>     | <b>Adverb</b>                         | <b>adjective</b>            |
|                               | <b>quality [time]</b>       | <b>Adverb or prepositional phrase</b> | <b>adjective</b>            |
|                               | <b>quality [place]</b>      | <b>Prepositional phrase</b>           | <b>noun premodifier</b>     |
| <b>5. relator</b>             | <b>entity</b>               | <b>Conjunction</b>                    | <b>noun</b>                 |
| <b>6. relator</b>             | <b>quality</b>              | <b>Conjunction</b>                    | <b>adjective</b>            |
| <b>7. relator</b>             | <b>process</b>              | <b>Conjunction</b>                    | <b>verb</b>                 |
| <b>8. relator</b>             | <b>circumstance</b>         | <b>Conjunction</b>                    | <b>prepositional phrase</b> |
| <b>9. entity</b>              | <b>(modifier of) entity</b> | <b>Noun</b>                           | <b>various</b>              |

The following, which are taken from examples 1 to 11 given above, illustrate the shifts outlined in **Table 2**:

1. present - presence (7)
2. form - formation (11)
3. particle dimension is increasing - increasing particle dimension (4)
4. washed completely- complete washing [manner] (5)  
transform simultaneously - simultaneous transformations [time] (11)  
hydroxyl groups on the surface - surface hydroxyl groups [place] (9)
5. Water concentration increased so the conversion of nitrogen increased<sup>27</sup> - The result of increasing water concentration was increasing conversion of nitrogen
6. Water concentration increased so the conversion of nitrogen increased - The resultant increasing conversion of of nitrogen was due to increasing water concentration
7. Water concentration increased so the conversion of nitrogen increased - Increasing conversion of nitrogen resulted from increasing water concentration
8. Water concentration increased so the conversion of nitrogen increased - Water concentration increased as a result of increasing water concentration (6)
9. CO oxides - CO oxidation (11)

For example, the metaphoric transformation of *present* to *presence* would represent a shift from ‘construed as a quality’ to ‘construed as an entity’, from ‘adjective’ into ‘noun’ and from the function of Epithet to that of Thing, as in 1) quoted above: *both oxygen and water are present.... by the presence of both oxygen and water.*

From what we have discussed, two considerations can be made: (i) in metaphoric transformation there is a general drift towards ‘thingness’. The direction of metaphor in a move towards the concrete and the noun is the most metaphorically attractive category; (ii) there is a close relationship between the two aspects of the metaphorical process: the shift in rank and the shift in function/class. Almost inevitably one displacement in rank and function/class will involve a number of others. So grammatical metaphors tend to occur in syndromes, clusters of interrelated transformations that reconfigure the grammatical structure as a whole.

However, given that grammatical metaphor involves two distinct moves in rank - clause nexus to clause and clause to group -, the syndromes of metaphoric features fall into two groups along the following lines:

- a) Lower rank syndromes: figures reconstrued as if elements  
[A figure, congruently construed as a clause, is instead reworded as a nominal group, which congruently construes an element]
- b) Higher rank syndromes: sequences reconstrued as if figures  
[A sequence, congruently construed as a clause nexus, is instead reworded as a clause, which congruently construes a figure].

I will illustrate both of these by referring to the examples 1) to 11) and to **Table 2**.

The lower rank syndromes are the clusters of features that co-occur in metaphoric nominal groups. Here the key metaphors are the nominalisation of quality (type 1 in **Table 2**) and process (type 2 in **Table 2**). These are accompanied by transformation of other elements of the figure, either participants (already realised as nouns, but change their function from Thing to Deictic, Epithet, Classifier or Qualifier, hence type 9 in **Table 2**), or circumstances (type 4 in **Table 2**). In the examples:

7) *presence of both oxygen and water*

1            9

(both oxygen and water are present)

7) *Reduction of nitric oxide* (Nitric oxide is reduced)  
 2 9

11) *simultaneous transformation* (transform simultaneously)  
 4 2

Metaphors of other types may also be involved in these lower rank syndromes:

1) *temperature-programmed calcination*  
 3 2  
 (calcined in conditions of temperature programming)

Moreover, any given nominal group may contain a number of these together:

1) *almost no possibility of O<sub>2</sub><sup>-</sup> formation* ([it] is almost not possible that O<sub>2</sub><sup>-</sup> is formed)  
 1 9 2

11) *Simultaneous transformation of both gold and support precursors during a temperature-programmed calcination*  
 4 2 9 4  
 3 2

(Because precursors of gold and supports are simultaneously transformed when they are calcined in conditions of temperature programming)

Higher rank syndromes are all the examples from 1) to 11), which were referred to earlier as the ‘favourite clause type’ in scientific writing. They consist of two nominalised processes or quality (each one a nominal group, where any possible lower rank syndrome may be present), joined by a verbalised relator (a verbal group):

1) *Theoretical molecular orbital calculation indicates almost no possibility of O<sub>2</sub><sup>-</sup> formation*  
 [4 9 2] 7 [1 9 2]  
 (According to the way molecular orbitals are calculated theoretically, it is almost not possible that O<sub>2</sub><sup>-</sup> is formed)

11) *Simultaneous transformations of both gold and support precursors during temperature-programmed calcination provoked the formation of Au catalysts highly active for the low-temperature CO oxidation*  
 [4 2 9 4]  
 3 2] 7 [2 9 4]  
 4 9 2]

(Because precursors of gold and supports are simultaneously transformed when they are calcined in conditions of temperature programming, highly active catalysts of Au are formed on which CO oxidises at low temperature)

One point must be finally noted. Lower rank syndromes are more directly associated with taxonomic categorisation, whereas higher rank syndromes are more directly associated with logical reasoning. The creation of technical taxonomies and chains of reasoning relate to the specific properties of a semantic that is stratified; namely its potential for referring and its potential for expanding. In fact, the semiotic power of referring is exploited as to create constructs of virtual objects that represent the distillation of experience, whereas the semiotic power of expanding is



exploited as to draw conclusions from observation and construe a line of argument leading on from one step to the next. Grammatically, these two discursive processes both depend on the same basic resource: the metaphoric transformation of a clause into a nominal mode of construal.

#### 4. The power of nominalisation

Grammar construes phenomena into classes. The primary resource for doing this is the vocabulary. A lexical item, like *spider*, constitutes an experiential category, more or less indeterminate at the edges but in explicit paradigmatic contrast with others, e.g. *bird*, *fish*. The lexis also allows for taxonomising, construing classes of classes: *scorpion*, *tick*, *mite*, *mygale*, *wolf-spider*, *cross-spider*, are classes of *spider*. The taxonomic relationship may or may not be made explicit in the word structure: in *scorpion*, *mite* it is not, whereas in *wolf-spider*, *cross-spider* it is.

It is in the nominal group structure that this taxonomising potential is fully realised, through the iterative character of modification. Taxonomies are already a feature of everyday language; the semi-designed registers of technology and science simply adopt the same potential and systematise its application. The prototypical form is of course the categorising of concrete objects in the perceptual world; and the organising concept is that of hyponymy: ‘*a* is a kind of *x*’, ‘a *myte* is a kind of *spider*’. In a taxonomy of this kind, the relationship is one of generality; the superordinate category is more general than its hyponyms. It is not any more abstract: a spider is not more abstract than a myte. It is simply a more inclusive set. But at the same time, assigning a class to a more general class is a theoretical operation. Thus *spider* becomes a theoretical construct and has a value in people’s theory of the living environment. If this ‘folk’ taxonomy is then reconstrued as an expert or a scientific taxonomy, the category *spider* is likely to get more explicitly defined, in an attempt to show what is in the category and what is outside it. This is a way of recognising both its place in the taxonomy, and its value as a theoretical construct.

In the course of this process, the meaning may get a new name: so a *spider* becomes an *arachnid*. *Arachnid* is, of course, merely the Latin word for ‘spider’. But a subtle change has taken place: it has now become a more abstract spider, a link in a chain of explanations of how species evolved. The metaphoric shift into another tongue symbolises the move to a higher, technical status and is typical of the technicalising process in many languages, and very markedly so in scientific English. In this regard, the new ‘spider’ - the *arachnid* - does function at a more abstract level. In becoming technicalised, it has also become condensed; it is no longer the name of a list of members but embodies certain other semantic features besides. The noun *arachnid* retains the category meaning of a noun but it has also some meaning as ‘theoretical abstraction’.

However, this opens up the possibility of extending the theoretical power of grammar still further, by technicalising elements which construe phenomena of other kinds: not only things, but qualities of things, and even processes themselves. Nouns like *width* and *radiation* construe ‘being wide’ and ‘radiat(e)/ing’ as theoretical entities. In doing so, they are exploiting a further resource, which has always been part of the grammar of everyday language: transcategorising, i.e. deriving one grammatical category from another. Specifically, they are exploiting the grammar’s potential for nominalising, turning verbs and adjectives into nouns. In *width* some quality and in *radiation* some process are being construed as if they were entities, as ongoing, stable phenomena. *Width* and *radiation* embody a semantic junction: *width* combines ‘entity’ with the feature ‘quality’ that is present in the adjectival form, *radiation* contains both the feature ‘entity’, which is the congruent meaning of the grammatical category ‘noun’, and the feature ‘process’, which is carried over from its original status as verb. It is in this case that the potential of metaphoric nominalisation in the grammar is fully revealed. A process, such as ‘radiate’, is observed, generalised, and then theorised,

so that it becomes a virtual entity ‘radiation’; as a noun, it now has its own potential a) for participating in other process, as in: “*the radiation is observed as it passes out through a small hole of the walls*”,<sup>28</sup> and b) for being expanded into a taxonomy, such as *thermal radiation, electromagnetic radiation, black body radiation*. Radiation realises a semantic junction and this means that the meaning of the term is condensed. The term *radiation*, now functioning as a theoretical abstraction, has undergone a semantic process known as distillation. A gradual ‘distilling’ effect of progressive nominalisation may be observed in this simple morpho-syntactic sequence in English: ‘radiates - is radiating - a radiating - radiation’; *body radiates - the body is radiating - a radiating body - body radiation*.

## 5. The pay-off of nominalisation: categorising and taxonomic organisation

Grammar construes phenomena into classes. The primary resource for doing this is the vocabulary. A lexical item, like spider, constitutes an experiential category, more or less indeterminate at the edges but in explicit paradigmatic contrast with others, e.g. bird, fish. The lexis also allows for taxonomising, construing classes of classes: scorpion, tick, mite, mygale, wolf-spider, cross-spider, are classes of spider. The taxonomic relationship may or may not be made explicit in the word structure: in scorpion, mite it is not, whereas in wolf-spider, cross-spider it is.

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In the course of this process, the meaning may get a new name: so a spider becomes an arachnid. Arachnid is, of course, merely the Latin word for ‘spider’. But a subtle change has taken place: it has now become a more abstract spider, a link in a chain of explanations of how species evolved. The metaphoric shift into another tongue symbolises the move to a higher, technical status and is typical of the technicalising process in many languages, and very markedly so in scientific English. In this regard, the new ‘spider’ - the arachnid - does function at a more abstract level. In becoming technicalised, it has also become condensed; it is no longer the name of a list of members but embodies certain other semantic features besides. The noun arachnid retains the category meaning of a noun but it has also some meaning as ‘theoretical abstraction’.

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radiation embody a semantic junction: width combines ‘entity’ with the feature ‘quality’ that is present in the adjectival form, radiation contains both the feature ‘entity’, which is the congruent meaning of the grammatical category ‘noun’, and the feature ‘process’, which is carried over from its original status as verb. It is in this case that the potential of metaphoric nominalisation in the grammar is fully revealed. A process, such as ‘radiate’, is observed, generalised, and then theorised, so that it becomes a virtual entity ‘radiation’; as a noun, it now has its own potential a) for participating in other process, as in: “the radiation is observed as it passes out through a small hole of the walls” (Day and Selbin 1962: 4), and b) for being expanded into a taxonomy, such as thermal radiation, electromagnetic radiation, black body radiation. Radiation realises a semantic junction and this means that the meaning of the term is condensed. The term radiation, now functioning as a theoretical abstraction, has undergone a semantic process known as distillation. A gradual ‘distilling’ effect of progressive nominalisation may be observed in this simple morpho-syntactic sequence in English: ‘radiates - is radiating - a radiating - radiation’; body radiates - the body is radiating - a radiating body - body radiation.

## 6. The pay-off of nominalisation: reasoning and logical progression

Categorising, taxonomising and distilling, which depend on the resource of the nominal group, are part of a sub-system within the overall semantic space that constitutes the experiential domain of grammar. However, technicality by itself would be of little importance unless accompanied by a discourse of reasoning: construing a flow of argument based on observation and logical progression. If we look at the following passage,

When radiation falls on a surface, some of the radiation is reflected and some is absorbed. The absorptivity of a surface is defined as the fraction of the light incident on the surface that is absorbed, and a black body is a surface that has an absorptivity of unity. That is, it absorbs all of the radiation that is incident upon it.<sup>29</sup>

We notice that the grammatical metaphor, *absorptivity of a surface*, has a discursive function: it carries forward the momentum of the argument. The grammar not only construes instances of human experience, but also has to construe itself by creating a flow of discourse. This is often referred to as ‘information flow’, but this term privileges the ideational meaning, whereas the discursive flow is interpersonal as well as ideational. It is as if the grammar is creating a parallel current of semiosis that interpenetrates with and provides a channel for the mapping of ideational and interpersonal meaning. The metafunctional component of the grammar that engenders this flow of discourse is the textual.

Many features contribute to the discursive flow; those that primarily concern us are those that form part of the grammar of the clause. The two systems involved are those of theme and information. The theme system is a system of the clause, where it sets up a structural pattern that we can interpret as a configuration of the functions Theme and Rheme. It maps the element of the clause onto a pattern of movement from a point of departure, the Theme, to a message, the Rheme.<sup>30</sup> The point of departure may be a consolidation of various elements; the part that is relevant here is its experiential module, defined grammatically as that part which has some function in the transitivity of the clause.<sup>31</sup> The thematic structure is realised lineally - the Theme comes first; furthermore, there is a strong bond between the textual system of theme and the interpersonal system of mood,<sup>32</sup> such that, if the clause is declarative, the same element will function both as Subject and as Theme. In fact, in the example given above, *the absorptivity of a surface*, Theme is conflated with Subject.

The information system has its own domain, the 'information unit', where it sets up a configuration of function Given and New. It maps the discourse into a pattern of movement between what is already around, the Given, and what is news, the New. The Given is what is being presented in the discourse as recoverable, to be taken as read; while the New is what is being foregrounded for attention.

The two systems are closely associated: the Given usually precedes the New, so that in the 'unmarked' case,<sup>33</sup> the Theme of a clause is located within the Given portion, and the New, that which is under focus, within the Rheme. What this means is that, typically, a speaker takes as a point of departure something which is already familiar to the listener, and draws attention to something that is the culmination of a message.<sup>34</sup>

It is this pattern of association between the information system and the thematic system which guides the readers - and the writers - of written text. The discourse of experimental science depends on an ordered progression: the first part of the paragraph of the example above, builds up the story of the observations which led to the development of a new quantum theory. This is stated, in a congruent form, as the first step in the illustration of a principle: *when radiation fall on a surface, some of the radiation is reflected and some is absorbed*. The next clause recapitulates what has been already said but the two figures, 'radiation + surface' and 'radiation + absorbed', become part of a larger motif in which they are functioning simply as point of departure. Previously, the figures occupied two clauses on their own: but now they have become the Theme of another clause, which is declarative, therefore, as we have seen, the Theme gets conflated with the Subject. Subjects are nominal groups, so the writer uses a nominalising metaphor: *the absorptivity of a surface*. The process 'absorbed' is now construed as a 'thing', *absorptivity*; and *the surface*, previously functioning as Identifier in an Identified + Identifier clause structure, now appears inside the nominal group as a postmodifying element *of the surface*.

Most noticeably it is the Theme that is metaphorised in this way: the writer carries the argument forward by 'packing' some semantic construct from the discourse to serve as point of departure for a further step. As already noted, there is a strong association between Theme and Given; so such packages are typically condensations of material that has gone before. It is important to reiterate, however, that the Theme may be not informationally Given; and in discourse such as that of written science, where the Given/Theme conflation is powerful and highly favoured, considerable effect may be achieved by departing from it, and considerable confusion may arise when such departure is unmotivated and unannounced.

There is, however, a tendency whereby such nominalised packages occur in culminative position in the clause, where they are Rheme not Theme and hence in strong association with the New. Fries refers to this conflation as 'N-Rheme'.<sup>35</sup> This is an important concept for written text because it embodies the culminative principle - that the way the writer ensures that something is read as New is by making it the Rheme of the clause. If we look again at the example given above, the N-Rheme, is *[a surface that has] an absorptivity of unity* is also a metaphoric nominalisation, one based on an established technical term, *absorptivity*. This is New in this particular clause but it also picks up on what the reader has just been told. It does not add any new content, but it moves up to a higher level of abstraction. It is only in the next clause, in fact, that the content will be given (*it absorbs all of the radiation that is incident upon it*).

The complex interplay of Theme + Rheme in the clause with Given + New in the information unit constitutes an immensely powerful discursive resource; it is the primary source of energy for the dynamic of scientific and technical argument.

## 7. Conclusion

The concept of grammatical metaphor does not imply a simple rewording: in shifting into the metaphoric mode, grammar actually creates new meanings and, therefore, new reconstructions of experience. In fact, a grammatical metaphor may enter a text instantially, i.e. created for the immediate requirement of the discourse, but then may become a systemic construct, i.e. created for the long-term requirement of the theory. When it becomes a new thing, a virtual entity, that exists as a part of a theory, it is 'dead' as a metaphor, because it has taken on a new non-metaphoric life of its own.

To conclude, two final observations must be made about the use of nominalisation and verbs in scientific discourse. Maurizio Gotti has analysed a sentence taken from Newton's *Treatise on Opticks* (written in 1675-87 and published in 1704), which already shows some typical features of the modern language of science: "Now those Colours argue a diverging and separation of the heterogeneous Rays from one another by means of their unequal Refractions". Gotti has noted: "the process of nominalisation enabled the scientist to include more information in the same sentence and guaranteed a better flow of discourse".<sup>36</sup> He has also pointed out that the verb in the quotation from Newton's text shows a tendency towards depersonalisation: "In fact, rather than use a form such as 'From those colours we could argue...', the author wrote: those colours argue..."<sup>37</sup>. With Newton, the process of language change was already underway.

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## Notes and references

<sup>1</sup> Halliday uses the term "construe" as a technical term: "By reconstrue I mean reconstruct semiotically, that is, replace one semiotic construction by another". Halliday M.A.K. (1998). Things and relations. Regrammaticising experience as technical knowledge. In Martin J. R. and Veel R. (eds). Reading Science. Critical and functional perspectives on discourse of science. London and New York: Routledge, 185.

<sup>2</sup> Ivi, 185-235.

<sup>3</sup> Ivi, 186

<sup>4</sup> Halliday explains "the term 'semantics' does not simply refer to the meaning of words; it is the entire systems of meaning of a language, expressed by grammar as well as by vocabulary. In fact, the meaning are encoded in 'wordings': grammatical sequences... lexical items... preposition". He also maintains that "in order to make explicit the fact that syntax and vocabulary are part of the same level in code, it is useful to refer to it as 'lexicogrammar'". Halliday M. A. K. (1985). An Introduction to Functional Grammar. London: Edward Arnold, xiv-xvii.

<sup>5</sup> Ivi, 184

<sup>6</sup> Halliday points out that "if something is said to be metaphorical, there must also be something that is not; and the assumption is that to any metaphorical expression corresponds another, or perhaps more than one, that is 'literal' - or, as we shall prefer to call it, CONGRUENT. Halliday M. A. K. (1985). An Introduction to Functional Grammar. London: Edward Arnold, 321.

<sup>7</sup> Halliday defines the functional elements in the nominal groups as follows: "Deictic. The Deictic element indicates whether or not some specific subset of the Thing is specified (the, this, these, that, those, my, your, our, his, her, its, their, Mary's, my father's, etc...)"; "The element we are calling 'Thing' is the semantic core of the nominal group. It may be common noun, proper noun, or (personal) noun"; "The element which follows the Thing [is the] Qualifier:.. [it] has the function of characterising the Thing"; "The Epithet indicates some quality of the subset, e.g. old, blue, fast. This may be an objective property of the thing itself; or it may be an expression of the speaker's subjective attitude towards it, e.g. splendid, silly, fantastic"; "The Classifier indicates a particular subclass of the thing in question, e.g. electric trains, passenger trains, wooden trains, toy trains... Sometimes the same word may function either as Epithet or

as Classifier... The line between Epithet and Classifier is not a sharp one". Halliday M. A. K. (1985). *An Introduction to Functional Grammar*. London: Edward Arnold, 160-167.

<sup>8</sup> Maurizio Gotti states: "The great epistemological and methodological developments taking place in [the 17th-century] determined the need for corresponding changes both in the ways of communicating the new discoveries attained by means of innovative procedures and apparatus, and in the expressive tool to be used to describe and argue about the new phenomena observed and analyse". Maurizio Gotti, "The Development of English as a Language for Specialised Purposes". In Cortese G. and Riley P. eds (2002). *Domain-specific English. Textual Practices across Communities and Classrooms*. Bern - Berlin - Bruxelles - Frankfurt - New York - Oxford - Wien: Peter Lang. 65. However inappropriate the term may be, 'modern' is generally used to refer also to 'contemporary'.

<sup>9</sup> Halliday maintains that "in the identifying mode, the meaning is 'a serves to identify the identity of x'. Here a and x are two distinct entities, one that is to be identified, and another that identifies it... What kind of relationship is there between these two entities? In the most general terms, the Identifier fixes the identity of the target element in one of two ways: either by specifying its form, how it is recognized, or by specifying its function, how it is valued. The two elements that are being related are the same in each case, but they are being looked at from opposite directions... This relation defines another pair of grammatical functions, which we shall refer to as TOKEN and VALUE. In any identifying clause, one element will be the Value (meaning, referent, function, status, role) and the other will be the Token (sign, name, form, holder, occupant). These functions are then conflated with those of Identified and Identifier". Halliday M. A. K. (1985). *An Introduction to Functional Grammar*. London: Edward Arnold, 115-116.

<sup>10</sup> Kozlov A. et al. (1999). A new approach to active supported Au catalysts. *Applied Catalysis* 182: 9-18, 26.

<sup>11</sup> Haruta M., Daté, M. (2001). Advances in the catalysis of Au nanoparticles. *Applied Catalysis* 222: 427-37, 429.

<sup>12</sup> Ivi, 430.

<sup>13</sup> In these examples the relation process is 'intensive' and it comes in the identifying mode. Halliday suggests that verbs of identification are: be, become, equal, form, give, form, express, constitute, imply, symbolise, realise, indicate, signify. Halliday M. A. K. (1985). *An Introduction to Functional Grammar*. London: Edward Arnold, 1985. 116.

<sup>14</sup> Porta F. et al. (2000). Metal sols as a useful tool for heterogeneous gold catalyst preparation: reinvestigation of a liquid phase oxidation. *Catalysis Today* 61: 165-172, 167.

<sup>15</sup> Haruta M., Daté, M. (2001). Advances in the catalysis of Au nanoparticles. *Applied Catalysis* 222: 427-37,433.

<sup>16</sup> Ueda A., Haruta M. (1999). Nitric Oxide Reduction with Hydrogen, Carbon Monoxide, and Hydrocarbons over Gold Catalysts. *Gold Bulletin* 32(1): 3-11, 7.

<sup>17</sup> Ivi, 11

<sup>18</sup> Porta F. et al. (2000). Metal sols as a useful tool for heterogeneous gold catalyst preparation: reinvestigation of a liquid phase oxidation. *Catalysis Today* 61: 165-172, 168.

<sup>19</sup> In these examples the relation process is 'circumstantial' and it comes in the identifying mode. Halliday suggests that 'circumstantial verbs' are: take up, follow, cross, accompany. Halliday M. A. K. (1985). *An Introduction to Functional Grammar*. London: Edward Arnold, 120. I would also add: lead to, give rise, provoke, suggest, cause, obtain, result in, depend on, increase, prevent.

<sup>20</sup> Kozlov A. et al. (1999). A new approach to active supported Au catalysts. *Applied Catalysis* 182: 9-18, 25.

<sup>21</sup> Tomishige K., Fujimoto K. (1998). Ultra-stable Ni catalysts for methane reforming by carbon dioxide. *Catalysis Surveys from Japan* 2: 3-15, 3.

<sup>22</sup> In these examples the relation process is 'possessive' and it comes in the identifying mode. Halliday points out that "in addition to possession in the usual sense of 'owning', this category includes abstract relations of containment, involvement and the like. Among the verbs commonly occurring in this function are include, involve, contain, comprise, provide... exclude, ... deserve,... lack, ... owe". Halliday M. A. K. (1985). *An Introduction to Functional Grammar*. London: Edward Arnold, 122.

<sup>23</sup> Haruta M. (1997). Novel catalysis of gold deposited on metal oxides. *Catalysis Surveys of Japan* 1: 61-73, 62.

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<sup>24</sup> Bond G., Thompson D. T. (2000). Gold-Catalysed Oxidation of Carbon Monoxide. *Gold Bulletin* 33 (2): 41-51, 46.

<sup>25</sup> See also Halliday M. A. K., Martin J. R. (1993). *Writing Science: Literacy and discursive power*. London and Washington: Falmer.

<sup>26</sup> Porta F. et al. (2000). Metal sols as a useful tool for heterogeneous gold catalyst preparation: reinvestigation of a liquid phase oxidation. *Catalysis Today* 61: 165-172, 9.

<sup>27</sup> The metaphoric expression of example 6) An increase in water concentration gave rise to increases in the conversion of nitrogen (Ueda and Haruta 1999: 7) may be congruently reworded as “Water concentration increased so the conversion of nitrogen increased”: all the examples quoted here from 5 to 8 are other possible metaphoric transformations of this congruent expression.

<sup>28</sup> Day M. C., Selben, J. (1962). *Theoretical Inorganic Chemistry*. Student’s edition. New York: Van Nostrand Reinhold Company, 4.

<sup>29</sup> Ivi, 3.

<sup>30</sup> Halliday, M.A.K. *An Introduction to Functional Grammar*. London: Edward Arnold, 1985, 39.

<sup>31</sup> Halliday, M.A.K. *An Introduction to Functional Grammar*. London: Edward Arnold, 1985, 101.

<sup>32</sup> Halliday, M.A.K. *An Introduction to Functional Grammar*. London: Edward Arnold, 1985, 44.

<sup>33</sup> Halliday, M.A.K. *An Introduction to Functional Grammar*. London: Edward Arnold, 1985, 45.

<sup>34</sup> It must noted that however related, “Given + New and Theme + Rheme are not the same thing. The Theme is what I, the speaker, choose to take as my point of departure. The Given is what you, the listener, already know about or have accessible to you. Theme + Rheme is speaker-oriented, while Given + New is listener oriented”. Halliday M. A. K. (1985). *An Introduction to Functional Grammar*. London: Edward Arnold, 278.

<sup>35</sup> Fries P. H. (1995). Themes, methods of development, and texts. In Hasan R., Fries P. H. (eds). *On Subject and Theme: A discourse functional perspective*. Amsterdam and Philadelphia: Benjamins, 317-359, 342.

<sup>36</sup> Gotti M. (2002). *The Development of English as a Language for Specialised Purposes*. In G. Cortese and P. Riley eds. *Domain-specific English. Textual Practices across Communities and Classrooms*, Bern - Berlin - Bruxelles - Frankfurt - New York - Oxford - Wien: Peter Lang, 65-86, 76.

<sup>37</sup> Ibidem.