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Tropes, science and communication

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1. Introduction

1.1 Language, science and communication

Compared to expert-to-expert – or peer-to-peer – communication, the language of popular science is characterised by a wider use of figurative devices. This applies to all forms of verbal and non-verbal communication. Specialized texts are characterised by a restricted and rigorous lexicon both in spoken and – even more so – in written language. Namely, a widespread use of terms which are monosemic, unambiguous and non context-dependent terms, and a minimum amount of natural linguistic choices. The few polysemic, ambiguous and context-dependent words encountered in a scientific text are highly functional, since meaning is mainly conveyed through field-specific terms.

The same rules apply to the iconography of a scientific text, where most pictures are graphs, diagrams or schemes. Their purpose is to give the reader a visual photo-like equivalent of the concepts discussed in the text. These images are all the more effective thanks to the use of colours, external references, highlighting and other devices, which make them functional to their explanatory purpose.

In popular scientific communication, iconography is used to evoke ideas and involve the reader in the text. The pictures often highlight a detail which unexpectedly discloses a whole new world; they show the stern or friendly features of a scientist, or suggest unexpected links between objects of a seemingly different nature. They thus make use of figurative language, which manages to overcome the strict limits of scientific rigour and objectivity, and re-presents ideas and theories in a different guise.

This duality – or rather this metaphorical nature – of the language of scientific communication is the focus if the present article. Scientists resort to figurative language in order to convey concepts originally developed by and addressed to a different audience. This device also allows them to shed new light on the links between different ideas. As a result, the semantic component of the terms themselves is inevitably altered and distorted, since they lose part of their technical meaning in order to enhance their evocative and connotative force.

The reason behind such a distortion, which often jars on scientists, is the difference in the communicative goals of expert-to-expert and popular scientific texts. Expert-to-expert communication aims to provide the linguistic tools that can be readily used by all members of the scientific community to promote their ultimate goal, i.e. to produce new science. Popular scientific communication, on the other hand, aims not to produce new science, but rather to explain and highlight all the essential logical connections for a readership whose background is very different. It is here that figurative language often proves to be a handy tool for effective communication.

1.2 Science and rhetoric

In dealing with the use of figures of speech in scientific communication, it is worth noting that a wide use of rhetoric occurs not only in popular but also in internal expert-to-expert scientific communication. The purpose is to facilitate the creation and discussion of new theories and to convince sceptics of the validity of these theories, methods and results.

According to Plato, rhetoric is the art of fine speech, the ability to persuade. Persuasion now more than ever pervades scientific conferences, articles and lectures. The twentieth century produced more scientific progress than ever before, and this inevitably implies that today's scientists cannot verify all the premises and results of their peers. When reading an article or, above all, a preprint, one has to trust the authors, relying upon their accuracy in verifying all their sources and in making their calculations. Things get even more complicated when it comes to experimental science:

in these areas it is virtually impossible for the reader, even for a scientist, to repeat the experiments and observations.

Having found out a new concept, it is the author's concern to fill the knowledge gap for other scientists and to make "proselytes". The more supporters a theory gains; the more it acquires credibility and, consequently, the easier it will be to receive further funds.

This explains the use of rhetoric in scientific articles, where now and then the writer aims at persuasion and fine writing. The text tends to develop a refined style, the purpose of which is, on a more or less conscious level, to be convincing. In mathematics, for instance, many examples are carefully chosen and are then presented as a general and exhaustive demonstration. This makes the text more concise and effective at the expense of meaning, because a particular case takes up a more general validity.

2. Science and tropes

2.1 Some fundamentals of rhetoric

Rhetoric is so deeply rooted in language that it is almost impossible to find communicative situations in which these devices do not occur. Rhetoric was initially used to persuade, i.e. to gain the approval of the recipient of the text. Later, however, it lent itself to a broader range of applications. Ghiazza (1985) defines rhetoric as the art of fine speaking and good style, an expressive and effective way of speaking, full of echoes and semantic nuances, which enriches language through an unusual and particular use of commonly used elements. The linguistic material at the author's disposal broadens and lends itself to manifold combinations, which innovate the linguistic heritage and stretch its limits. Thanks to an unusual and unexpected collocation, a word which has lost its semantic force can come to new life in a new context.

We shall now briefly look at the main tools of classical rhetoric, starting from the traditional distinction between *figurae elocutionis, figurae sententiae* and *tropes*. The first group includes the simplest figures of speech concerning single words, both as regards phonetics (onomatopoeia, alliteration, homoioteleuton, etc.) and position in the sentence (anacoluthon, hypallage, prolexis, etc.). According to Ghiazza (1985), the *figurae sententiae* refer to a reformulation of concepts and to original connections between ideas. These proceedings, among which simile, antithesis and chiasm, can alter the word's semantic components. Tropes occur when a word undergoes a semantic change and takes up a different meaning from its literal meaning. Examples of tropes are **metaphors** (*similitudo brevior*), **allegories** (a symbolical interpretation), **metonymies** (the substitution of the name of an attribute or adjunct for that of the thing meant (Oxford 1995): cause/effect, abstract/concrete, container/content, object/the material it is made of, author/works, symbol/its meaning), **synecdoche** (a part is made to represent the whole, the singular is made to represent the plural or vice versa), **antonomasia** (the substitution of an epithet or title for a proper name), **euphemisms** (the substitution of a mild or vague expression for one thought to be too harsh or direct), **litotes** (apparently mitigating the meaning, but actually strengthening it, by expressing an affirmative by negating its contrary), **hyperboles** (an exaggerated statement not meant to be taken literally) and **irony**. Rhetoric operates at the language level, but also, more or less frequently, at the situational or contextual level of communication. This takes us back to the main issue of the function underlying each communicative act. Bühler identifies three main linguistic functions, but normally a speech act does not express one single function, as there often is an overlapping between two or more functions. According to Bühler's theory, which was further developed by Jakobson and Newmark, the main linguistic functions are the expressive, the informative and the vocative. Each of these reflects the prevailing component of any communicative act: the expressive function focuses on the writer/speaker, the informative function on the extralinguistic context and the vocative function on the recipient of the text. This distinction helps us recognize the differences between the main function of a specialized scientific text and one with a popular readership. Popular scientific communication seeks a balance between the attention devoted to the writer, the recipient and the contents of the text. This results in a hybrid between technical and literary/journalistic texts, which do not have a set of characteristics of their own. Their distinctive features can rather be traced by comparing these texts with others belonging to similar genres, and pointing out analogies and differences.

2.2 Rhetoric and internal scientific communication: scientific texts

Traditional scientific texts, that is texts about science that use the language of science, belong to a well-defined textual typology. The text has to adhere to certain conventions in order to be recognized by its intended readers and to make clear from the very beginning – or even from the title – the degree and the kind of knowledge necessary to decipher it. Highly specialized texts tend, according to Scarpa (2001), to stick closely to the textual conventions of the genre they belong to, so as to meet the expectations of the readers and make communication easier.

Despite the presumed non-emotionality and objectivity of scientific texts, the author may resort to rhetorical devices to catch the attention and increase the involvement of the reader.

According to Kocourek (1982), it can be proven that scientific texts can have emotive elements. The language of science tends to be impersonal, but may contain value judgements which connote demonstrations, criticism and agreement, with traces of hidden emotions, admiration, irony and contempt[1].

An analogy can then be traced between scientific and journalistic texts, where the authors recount objective and unquestionable facts, but where their the point of view shines through the text together with their intention to convince the audience of the validity of their statements.

In both textual typologies the main function is the referential function: the author intends to update the reader’s knowledge on the subject through more detailed information. The vocative function can also be traced, which helps to create an empathy between reader and writer by means of opinion and information-sharing on the subject.

This flow of information usually follows a dynamic scheme based on the progression of theme and rheme. The given element, that is information traceable in the co-text or in the context, and therefore presumably shared with the reader, can be identified with the theme (beginning of the sentence) and the subject. The new element, on the other hand, adds information to the theme and can be identified with the rheme (end of the sentence). Once the theme has been presented to the reader, it becomes a given element and can act as theme in the following sentence. Theme-rheme progression is very similar to the expounding of a scientific theory.

Distinguishing between the stages of production/development and formalisation/ presentation of a new theory is not easy, of course. The cut-off could be the opposition between isolation and communication. Formalisation/presentation is clearly the exterior

[1]According to Sabatini, the high density of technical terms and the rigour of the form and the style make this type of texts “highly binding” (in Scarpa 2001).

representation of what is called horizontal communication, that is the official exposition of a new theory by a scientist to other experts. At this point rhetoric comes into play, because the author tries to establish an internal consent around his/her theory.

Production/development relies upon the concept of isolation, a typical element related to creation. When generating a new idea, the authors automatically remain in an isolated environment. This peaceful condition allows scientists to organize their thoughts from chaos into ideas. Creating requires solitude. The participants in the creative process have to form a monad.

Thus scientific thought is spit two ways: on one side there is the solitude of the creator, on the other the overcoming of this solitude thanks to a formalized communication of what has been produced.

Electronic archives have taken up an important role in academic communication, since they offer new spaces and new ways of exchanging information within a scientific community. It is hard to tell where the writing of a paper ends and the crystallization of procedures, concepts and results begins. Nowadays, the writing process is very dynamic, writers can consult preprints, quickly exchange ideas and opinions with one another and, what is more important, read more versions of the same article at different stages of updating. Scientific writing is becoming more and more persuasive and it is more flexible and open to a confrontation among experts, but the number of publications is exceedingly high[2].

Because preprints are published in archives as rough drafts, scientific thinking is mixed with persuasive devices and elements of doubt, which should be beyond the boundaries of science, logical thinking, scientific experimentation and demonstration. Still, these features do exist in such texts and can actually influence the final draft of the article.

Yet, things seem to be even more complex, connected not so much with the advent of electronic archives and published preprints, but rather with the nature of communication itself. If, as we said, rhetoric is the art of fine speaking, it is reasonable that a fine manner will be more or less consciously chosen in scientific writing as well.

Languages for special purposes have evolved and have become consolidated because they make communication easier. A message is conveyed with fewer words, and learning is facilitated for scientists entering a new community of experts such as a research project thanks to the use of technical terms with a high semantic density. As Pucci (1997) said, the reason behind this mechanism is economical: a highly dense terminology allows an individual to learn the linguistic conventions of the subject in a shorter time.

[2] See *Principles for Emerging Systems of Scholarly Publishing*, at http://www.arl.org/newsltr/210/principles.html.

3. Some features of scientific texts

3.1 Tropes and frequency of technical terms

Because of their non-ambiguity and effectiveness, technical terms frequently occur in a scientific text and are seldom found in common language, where meaning is mainly conveyed through the context[3].

However, although the rigour typical of science requires the use of a specialized discourse, a certain amount of ambiguity and indefiniteness are also present. An absolute one-to-one correspondence between words and meaning is just an illusion, even in scientific texts. Some ambiguity must be preserved, and indeed, as Tito Tonietti says, communication relies on it, for in some way it is ambiguity that gives structural stability to the text (Tonietti 1983). Thanks to ambiguity, or rather metaphorical language, manifold representations of the same fact or the same truth can be given, and a number of concepts can be expressed through fewer lexical items.

It is the tropes that realize ambiguity, because they allow the same concept or idea to be expressed through different signifiers. The risk is that signifiers may overshadow the signified. Rutherford's solar model of the atom probably caused misunderstandings and oversimplifications on the part of many physicists – and certainly many students. The hyperbole of electrons revolving around the nucleus was so effective that it took root in human knowledge and even hindered a correct understanding of the atomic structure.

The excessive use of figurative language in scientific communication could lead to what we may call the paradox of credibility: while scientific discourse is traditionally expected to be rigorous and consequential, figurative language inevitably makes it vague and ambiguous, drawing it further apart from readers' expectations. Moreover, figurative language tends to make scientific texts as obscure as technical terms do. Thus, figurative language proves to be necessary on the one hand in order to make communication more effective, but risky on the other hand, since it lacks credibility and contrasts with the rigour expected from science.

The contrast is not so clear-cut when it comes to more metaphorical and rhetorical disciplines such as cosmology, biology or anthropology. In these areas the

[3] See Taylor (1988) for the distinction between lexical density and term density.

opposition between figurative language and intrinsic rigour is clearly weaker, so the gap is smaller.

3.2 The local property of non-ambiguity

Ambiguity and uncertainty are inevitable in the choice of a descriptive model or a term representing a situation, or even in the definition of a concept intended to be the core of a new theory. According to Heisenberg, the intrinsic uncertainty of the meaning of words was noticed a long time ago and it led to the need for definitions. "Defining" a word literally means to mark out the boundaries of its meaning, thus making clear when it can and cannot be used. A definition, however, can only be expressed through other concepts, so in the end some notions will have to be accepted without any proof or explanation (Heisenberg 1961). This observation leads to two significant indications on the relation between language and scientific communication. Firstly, Heisenberg points out that a definition delimits the range of use of the term, which makes it monosemic and unambiguous. These characteristics are thus context-dependent, local properties of each word. What Heisenberg does not say, however, is that definitions set limits to the users of terms as well, who are compelled to respect the term's boundaries.

Secondly, definitions rely upon concepts which have not been carefully analysed and defined, which justifies the use of tropes even in pure science.

Tropes are obviously used very differently in a scientific and in a non-scientific context. By definition, tropes establish a connection that stretches the term's range of use. They usually refer to something external from the term's common usage. If not so, tropes give at least the context a broader interpretation.

Generally speaking, the lower the density of the terms, the higher the number of connections the reader needs to understand the text. As the density increases, the reader becomes more independent and can follow the text without resorting to metaphorical connections. This is one reason for the low occurrence of tropes in highly specialized communication.

Moreover, in the language of science tropes (and metaphors in particular) are often implicit and totally integrated in the definition of the term.

Boyd divides the metaphors used in scientific discourse into two groups: exegetical or pedagogical metaphors, "which play a role in the teaching or explication of theories" (Boyd 1993: 359) and are typical of expert-to-non-expert communication (didactic and popular texts), and theory-constitutive metaphors, which “are constitutive of the theories they express” (Boyd 1993: 360) and are typically used in expert-to-expert communication (Scarpa 2001). It should be borne in mind that there is no real borderline between the two groups, and that a scientist, when coining a new label, is influenced by both the scientific process that led to that new object or idea and factors such as culture, personal experience or the age he or she lives in. Examples of conceptual metaphors are the big bang, black holes, the colour and flavour of a quark, the DNA helices, abundant numbers, twin prime numbers…

These kinds of metaphors can refer to non-scientific elements and therefore connect scientific knowledge and popular beliefs. This is the second reason for the low occurrence of tropes in scientific texts: terms containing metaphors are used instead of tropes, and it is these terms that connect science to other contexts.

Finally, it is interesting to note that in scientific texts devices similar to tropes are frequently used at a structural level. When, in a paper or a lecture, the writer (or the speaker) focuses attention on some particular case which summarizes and exemplifies the general topic of the discussion, a part is made to represent the whole, just like in a synecdoche. Terms used to refer to ideas and concepts often reflect their peculiarities (antonomasia, e.g. characteristic polynomial), or display a hint of irony (e.g. a quark’s colour and flavour), or exaggerate a particular feature (hyperbole, e.g. the atom, which can be split but is still obviously called a-tom). And then scientific discourse abounds in significant results (think of all the Fundamental Theorems in Mathematics). Shouldn’t scientific breakthroughs owe their impact on society only to their intrinsic significance? Still, the stylistic choices of many scientist recall the use and the effect of tropes.

3.3 Scientific discourse

Let us now compare rhetoric and science in greater depth. The classical model divides rhetoric into *actio* (the final delivery, with the appropriate gestures and diction), *dispositio* (organising the text), *elocutio* (the ornamentation of the speech) and *memoria* (memorising the text). This closely resembles the process of presenting and formalizing new scientific ideas, concepts and theories. After the conceptualisation and the production phase, in order to present and formalise new theories the scientist has to follow the same path: *dispositio, elocutio, memoria, actio*.

The analysis of scientific texts shows that, even in internal communication, scientists resort to rhetorical devices to enhance the text's rhetorical effect. *Elocutio* shows through even in an article of Mathematics, where the structure of the text highlights some utterances, statements and propositions. It is as if the author were saying to the reader "Look, this is a theorem, this is a definition, this is a corollary!" According to the rigorous and consequential standards of Mathematics, the author states clearly that logic is logic, and a consequence actually is the result of logical thinking.

The occurrence of rhetorical devices – especially those related to the *actio* – is even greater at the stage of conceptualisation. Gouthier (2001) refers to informal mathematics as the grouping of the informal attitudes, exchanges and chats that are frequently – though more or less consciously – used by the members of the mathematical community when conceptualising a new concept. It has actually been proven that informal maths plays a significant and effective role in communication within the mathematical community, as the filmed interview with Ennio De Giorgi clearly demonstrates (Emmer 1996).

4. Scientific communication and figurative language

In scientific communication a linear thematic progression is essential for both quantitative and qualitative reasons. The first reason concerns the widely-held belief that scientific texts are difficult to understand. Authors of scientific texts should therefore restrict the maximum amount of information to be conveyed and present it in a logical progression, so as to guide the reader in the learning process. The qualitative aspect refers to what may be considered "given information", that is a knowledge shared by the highest possible number of readers. In general, scientific texts tend to adhere to both of these precepts insofar as they usually follow a linear thematic progression, keep the density of new information low – that is they do not go into details – and make references to everyday experience to catch the reader's attention. Since most readers will be familiar with features from daily life, they have thus become ideal terms of comparison.

Scientific texts often begin with a reference to daily life, which exemplifies the subject matter. In a sense, this approach is a metaphor, or, more precisely, an exegetic metaphor.

By linking the presentation to an event from daily life, the author contextualizes the topic of the discussion and has the reader take a positive attitude towards science, usually regarded as incomprehensible. The general public looks for useful answers, which satisfy their needs. That is why they show an interest in technical and technological aspects, which aim to solve problems in real life, rather than aiming at knowledge for its own sake, as science does (Thom, 1985).

In this case, scientific communication is triggered off by a need (its application in daily life), which can only be satisfied by recourse to technological aspects of the scientific concept itself.

To avoid misunderstandings and let the public believe that science and technology are basically the same thing, the communicator has to ensure that, after a few lines, the reader can take as given, known and clear (theme) what until some minutes earlier was new and unknown (rheme). If this process is not fast enough, readers will rarely go beyond an answer to the question "what is it for?".

As the text progresses, the writer has to keep the reader focused by continuously referring to technology, daily life or ordinary needs, even if the rules of discourse call for a more sober approach. The use of tropes clearly helps to catch the reader's attention and link an abstract concept to daily experiences. Thematic progression often moves from the example to the rule, or from a particular case to a general statement, through a process of gradual generalization. Each example is more general than the one that precedes it and a metaphor of the even more general one that follows. The goal of scientific communicators is to establish the links for a conceptual progression.

Daring logical connections are often acceptable, provided that references to other scientific concepts, non-scientific knowledge or even non-scientific experience shared with the readers be given. A very good examples is Claude Lévi-Strauss's Man representing the Earth's cancer. Argumentation revolves around interrelations between the evolution of humanity and medical references to a hypothetical diagnosis for the patient Earth.

The documentary “Fermat’s Last Theorem”, broadcast by the BBC in the series *Horizon*, follows a more abstract line of thinking: Simon Singh uses a mathematical device to support the Taniyama-Shimura hypothesis. This theory, stemming from Fermat’s last theorem and demonstrated by Andrew Wiles, establishes a natural link between two theories which apparently have nothing to do with each other, namely the theory of elliptical curves and that of modular forms. When speaking of the Taniyama-Shimura hypothesis, Singh’s documentary shows the Golden Gate or some other famous bridge, so this representation of a link remains in the viewer’s mind even if s/he can’t entirely understand the mathematical reasoning behind it. To the audience, the bridge definitely appears more tangible and real than Fermat’s theorem or Taniyama-Shimura’s hypothesis. It is an abstract representation for the connection: it is a metaphor. This metaphor is all the more effective since the documentary shows a different bridge every time, which takes on a symbolic value.

Singh’s bridge is an effective metaphor for the shift from internal to general scientific communication as well. The starting point is signalled by the three features that favour the use of tropes in scientific communication: high frequency of technical terms, the use of conceptual metaphors and the recourse to devices similar to tropes. These features do not apply to scientific communication the way they stand. Even though definitions maintain some evocative power[4], both technical terms and pseudo-rhetorical devices cannot be considered typical tools of scientific communication.

Science and scientific communication use tropes differently. Science resorts to similes when it reinforces a general theorem through particular examples, while scientific communication uses metaphor the other way around, starting from a technological application and moving to the general rule of scientific theories.

Thus, polarization characterizes the way scientific discourse and communication make use of tropes. On one hand, there are scientific texts addressed to experts in a scientific community, which, as we said earlier, do not allow the use of tropes. On the other hand there are popular scientific texts, aiming at spreading scientific knowledge. In these kinds of texts tropes have to be used to lower the density of scientific content

[4] The images evoked by these metaphors, however, tend to confuse the reader. The expression “colour and flavour of a quark”, for instance, makes the reader think of feelings which actually have nothing to do with a quark’s properties. In the case of black holes, things are even worse, since the reader focuses the attention on the word “hole”, which gives a feeling of absence, while the physicist focuses on the word “black”, which refers to the obscurity of the matter inside the hole.

and to enable the reader to make a mental shift from satisfying a technological need to acquiring some scientific knowledge, though limited and partial.

Between these text types the communicator has to collocate the need to coin new terms and create a new language which allows the shift from doing science to communicating science. The communicator shares with the scientist the need of giving the reader definitions, since, as Heisenberg says, definitions mark out the boundaries of meaning. But they mark out the boundaries of the audience as well, distinguishing between those who can use the definition and those who cannot. A good communicator should know how to shape communication according to the contents of the text and the reader. In this regard, tropes play a decisive role.

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Bibliography

Boyd R., “Metaphor and theory change: what is a metaphor for?”, in *Metaphor and Thought,* A. Ortony (ed.), 2nd edition, Cambridge University Press, Cambridge, 1993, pp. 356- 408.

Bühler K., *Sprachtheorie*, Fischer, Stuttgart, 1965.

Emmer M., *Intervista a Ennio De Giorgi*, film, 75 ', Unione Matematica Italiana, 1996.

Ghiazza S., *Elementi di Metrica Italiana e Cenni di Retorica*, Edizioni Levante, Bari, 1985.

Gouthier D., “Termini e linguaggio per comunicare matematica”, in *Jekyll.comm – International Journal on Science Communication*, II, 2002 (http://jekyll.sissa.it/ jekyll_comm/articoli/art02_03.htm).

Heisenberg W., *Fisica e filosofia*, Il Saggiatore, Milano, 1961.

Kocourek, R., *La Langue Française de la Technique et de la Science*, (1st ed.), Brandstetter, Wiesbaden, 1982.

Lévi-Strauss C., “L'uomo, malattia del pianeta Terra”, in *La Repubblica*, 9 marzo 2000.

Miller, A. I., *Insights of Genius: Imagery and Creativity in Science and Art*, Copernicus, New York, 1996.

Newmark P., *A Textbook of Translation*, Prentice Hall International (UK), 1988.

Oxford Encyclopedic English Dictionary, (2nd ed.), Oxford University Press Inc., New York, 1995.

Pucci C.R., “Norma terminologica e linguaggio speciale”, in *Atti della tavola rotonda “La terminologia tecnica e scientifica: attualità e prospettive"*, Roma, 1997.

Scarpa F., *La Traduzione Specializzata*, Hoepli, Milano, 2001.

Taylor C., *Language to Language. A Practical and Theoretical Guide for Italian/ English Translators*, Cambridge University Press, Cambridge, 1998.

Thom R., “Tecniche, scienze e tecnologie: una classificazione catastrofica”, in *Prometheus*, Franco

Angeli Editore, Milano, 1985.

Tonietti T., *Catastrofi*, Dedalo, Bari, 1983.