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Medical Research Papers and Their Popularization. A Macro- and Micro-Linguistic Qualitative Genre Analysis

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Abstract

Communication between the scientific community and the general public is not always effective. There is a meaningful discrepancy that needs to be bridged, mainly because scientific knowledge is produced not only for a restricted specialized community but also for a general target, as part of a crucial social responsibility. The need to fill the gap is even more relevant in medical research as its findings are perceived of direct interest by the public.

The process of making specialized knowledge understandable to laypeople is known as *popularization* (Nash 1990) or *popular scientific writing* (Calsamiglia 2003), which includes knowledge dissemination in popular magazines, scientific news reports in newspapers and television documentaries. Popularized articles are usually written by journalists who are expert in a specific field and who act as mediators, recontextualizing scientific findings to make them useful and attractive to the large public.

In this study we will analyze two medical texts; the first is a research paper about a biomedical topic written and published in English, while the other is a popularization written in Italian and published in the magazine *Focus*. The purpose of our research is to carry out a qualitative linguistic analysis of the two texts and highlight similarities and differences in their structure and linguistic features, to identify their fundamental constitutive traits, and establish whether they belong to two distinct textual genres or whether one is the adapted version of the other, always referable to the same genre.

What we infer from the results of our investigation is that we can assign the two texts to two different genres, having not only different constitutive traits, but also different target audiences and different communicative purposes.

Keywords: Genre analysis, Popularization, Medical science, Textual genre transformation, Language for special purposes

1. Introduction

The main goal of this study is to provide, through a one-to-one qualitative analysis, a genre classification of research specialized texts and their relative popularizations. Many authors (see Section 2) working in this field consider these two categories of texts as a unique whole, which was then adapted to reach a wider audience. Instead, we claim that they are related but distinct textual genres. They are related because they talk about the same topic, and different because they show different structures, lexical features and different purposes and are addressed to different audiences.

We substantiate our hypothesis by analyzing two texts within the domain of medical discourse: a research paper, *Gallium disrupts bacterial iron metabolism and has therapeutic effects in mice and humans with lung* infections, published in the medical review *Science Translational Medicine*[1] and its corresponding popularized version *Un pasto avvelenato per i superbatteri resistenti agli antibiotici* ('A poisoned meal for antibiotic-resistant superbacteria'),[2] appeared in a famous Italian magazine *Focus*. The two texts deal with the same topic, a biomedical discovery made by a team of American researchers, who tested the usage of gallium instead of iron to target and eliminate a group of bacteria.

We analyzed in depth the various sections of the two texts with reference to their microlevel and macrolevel. The first one refers to specific lexical components, such as vocabulary, register, lexical phenomena (e.g. definition, denomination, exemplification, etc.) that characterize a text, while the other one refers to the more general shape of its structure (e.g. position of arguments and sections, rhetorical moves etc.). Our investigation, described in Section 3, reveals, through the analysis of the above characteristics, that research papers and popularized articles have different constitutive traits at the above-mentioned levels.

The use of a different register, of specialized lexis in contrast with common vocabulary, of simple phrasal structures instead of more complex ones, of typical rhetorical moves that provide the reader with different contents at different stages of the texts, exemplify and give substance to our assumption that research papers and popularizations are two different textual genres.

This gives a new status to a popularization literature, since it is no longer qualifiable as a mere manipulation, a partial simplification of the more authoritative scientific production, but is rather autonomous, with its own purposes, its own target public and its own features.

The innovative aspect of the study lies in this equal interpretation of the status of these two textual genres, previously seen as degrees of a unique gradual continuum (see Section 2), each of them with its own stylistic and structural constraints, mainly depending on the type of information that each of them has to convey.

[1] The research article has been published in *Science Translational Medicine* by Goss et al. (2018) and is available for consultation at the following address: http://stm.sciencemag.org/content/10/460/eaat7520

[2] The popularized article is available for consultation at the following address: https://www.focus.it/scienza/salute/batteri-resistenti-agli-antibiotici-pasto-avvelenato

As discussed in Section 4, the qualitative analysis gave us on the one hand the opportunity to conduct a careful investigation of the selected texts, but on the other reduced our findings to this sample. We are aware that a wider corpus of texts would allow us to process data at a quantitative level too, and to extend our observations, which we aim to do in a future investigation. However, a first qualitative investigation was, in our opinion, helpful to isolate the essential elements of the comparison between the two texts and confirm our initial assumption.

2. Theoretical Background

Traditionally, scientific discourse has been associated with the special purpose language employed by scientists in their laboratories or, perhaps more accurately, in their conference papers, journals, scientific articles, and textbooks (Roth 2005).

The development of each scientific domain is tightly linked to the presence and usage of this kind of specialized discourse, since it shapes scholars' ideas and promotes the development and dissemination of new discoveries and theories among the members of the scientific community. This language shows some typical characteristics; in particular, it is intentionally deprived of values, emotions and aesthetics, in order to appear as reliable and authoritative as possible (Bhatia 2004, 2008; Swales 2004).

Popular science, instead, is commonly seen as an interpretation of science, produced for the general public, rather than for scholars. According to Calsamiglia and van Dijk (2004), science popularization is a "large class of *discursive-semiotic practices*, involving many types of mass media […] *aiming to communicate lay versions of scientific knowledge*, as well as opinions and ideologies of scholars, *among the public at large*" (Calsamiglia & van Dijk 2004: 371).

Popularization is widely intended as an attempt to disseminate scientific outcomes outside the boundaries of the community of experts that developed them and that is supposed to own such knowledge (Giannoni 2008). As Myers (2003) and Hilgartner (1990) claim, such an interpretation lies in the distorted opinion that only specialists can access authentic scientific knowledge, whereas popularized notions are mere simplifications of that knowledge for laypeople. This idea implicitly suggests the existence of a hierarchy between scientists and non-experts, being the former the only ones who possess legitimate knowledge. According to this point of view, the production of specialized knowledge, within a certain scientific community, and lay knowledge, made by and for people outside this same scientific community, seem to be identifiable in two likewise different genres of discourse: thus, popularization becomes a recontextualized reformulation of a scientific source text in order to make it accessible to varied audiences (Ciapuscio 2003; De Oliveira and Pagano 2006). However, if popularization is simply a mere recontextualization, not only a distinction between scientific and popularized knowledge would be required, but also a clear-cut identification of the borders existing between original scientific knowledge and its popularized version, or worse, distortion. Even if a continuum exists between *pure* science and *pure* popularization (Widdowson 1979), these borders can be determined analyzing the vocabulary, degree of specificity accuracy, syntactic structure etc. proper of the two genres.

According to Gotti (2003, 2012) these two textual genres are chiefly distinguished by two key aspects: the kind of audience and the function of the text. In popularized texts, Manfredi (2014: 152) assigns the role of 'specialist' to the writer, an expert in the field who shares scientific discoveries or particular issues with a non-expert public, defined as "a wide audience of educated, and interested, laypeople". Research papers, instead, are written by experts for other experts.

Concerning the function of popularized articles, their primary aim is, clearly, to inform readers, but not necessarily to train them. As a matter of fact, unlike educational texts, whose aim is to train nonspecialist students in terms of knowledge, concepts and specific terminology, popularized texts convey specialized notions to non-expert readers by using everyday language because of their usefulness and impact on everyday life. Olohan (2016: 196−197) assumes that popularized discourse does not merely serve to inform an otherwise ignorant public; on the contrary, "readers relate this discourse to their own knowledge, opinions and beliefs". Furthermore, Olohan (2016: 174) highlights how popularization is often understood as "the simplification, distortion or dumbing down of science". The author, however, believes that "popular science genres can be regarded as scientific genres in their own right, rather than simplified versions of professional science" (Olohan 2016: 203), adding that it would be helpful to think in terms of different degrees of popularization. Research papers, instead, have the main function of spreading new discoveries and new knowledge within the scientific community of reference.

According to what has been said so far, the term *popularization* has assumed different meanings, thus requiring a process of classification. On the one hand, we have texts that are produced to present scientific knowledge in an understandable and meaningful way, addressed to laypeople; on the other, we place those texts used by expert members of the scientific community to disseminate highly specialized knowledge in contexts accredited for this purpose (cf. Table 1).

Table 1. Characteristics of the discourse of popularized science and of scientific popularization

	Discourse of scientific dissemination	**Discourse of popularised science**
Purpose	Sharing knowledge among experts	Simplifying and disseminating knowledge
Target audience	Homogeneous; members of the scientific community	Diversified; lay people
Medium	Scientific articles, conference papers, laboratory talks, project proposals, policy documents etc.	Mass media, newspapers, web-communication tools (blogs, forums etc.)

There are many reasons that justify the current need for popularizing science. First of all, due to the possibility to directly access the sources of scientific data, which is guaranteed by mass dissemination tools such as the Internet, laypeople require an augmented awareness of what kind of research is being conducted to evaluate any social, ethical or political implication.

Furthermore, "the general public should understand what science and technology can do, and what are the implications of certain forms of interventions." (Garzone 2006: 82)

Together with audience and function, implications of any kind (e.g. social, ethical or political) rise in the linguist expectations for occurrences of evaluation in a popularization and links between language and ideology. Considering and analyzing them might help highlight reasons behind or beyond objective and subjective style in the two text types/genres under scrutiny.

2.1 Characteristics of Specialized and Popularized Medical Scientific Texts

Given that specialized and popularized scientific texts are attributable to distinct textual genres, as hypothesized in this study, they are supposed to show peculiar linguistic and structural characteristics that differentiate them from each other. We define here the notion of *genre* as a set of communicative events with well-established goals, which are shared by the members of a discourse community (Swales 1981, 1990; Bhatia 2008). What makes these events a proper textual genre, then, are their communicative purposes, shared by the members of a discourse community, that set the constraints of the discourse, in terms of structure and linguistic features.

Analyzing the characteristics of medical discourse as expressed in research papers, addressed to experts, and popularized articles, addressed to laypeople, Brand (2008) distinguishes two levels, an internal and an external level: "Communication at the internal level takes place between experts exclusively within the field. Both the authors and the recipients have received a particular education and gained qualifications in this field so that they are of course familiar with the highly codified medical language and terminology. […]. External communication is intended for laypeople" (Brand 2008: 2). Table 2 provides a schematic explanation of Brand's distinction.

Table 2. Two levels of the same scientific discourse

TOPIC	LEVEL	AUDIENCE	GOAL	TEXT GENRE
Medical	Internal	Restricted to medical professionals sharing a specialised education and knowledge.	Objective description of relevant facts within the selected scientific field, and relative discussion.	Research article, bulletin in medical journals, conference papers.
	External	Generally referred to laypeople without	Popular broadcast of the events, infotainment. Great attention is dedicated to the	Written media, newspapers addressed to the general public, with the aim of

		a common educational and professional background.	emotional involvement of the readers, to increase their attention and interest.	broadly informing about important discoveries or situations of particular interest for the readers.

As illustrated in Table 2, medical scientific discourse is organized in two different stages: the first one refers to the medical scholars' discourse, which deals with health themes within the boundaries of their specialized field and is characterized by an objective and analytic style. The other one is focused on the external communication, the aim of which is to inform laypeople about the latest and most interesting news in the health domain. Since this type of text is addressed to readers without any specialized knowledge in that field, it tries to present complex scientific information in a familiar and easily understandable way.

The passage from one level to the other requires a genre shift according to the degree of popularization produced, within which the textual structure can change both at a macrolevel (referring to the structure of the article) and at a microlevel (referring to lexical choices, sentence structure, etc.).

2.1.1 Differences at a Macrostructure Level

At a macrolevel, popularized texts show a considerably reduced set of information compared to research articles. The two genres also make use of different rhetorical moves to shape their structure. Medical research articles are governed by an IMRD structure, including the *Introduction, Methods, Results, and Discussion* sections, as stated by Nwogu (1997). The author uses Swales' genre analysis model (1981) to investigate the macrostructure of discourse organization in research papers, elaborating an 11-move schema that would also be further adopted by Fryer (2007, 2012). This approach aims to identify recurrent rhetorical moves in this genre, each of them being made of several steps. Table 3 describes Fryer's (2012: 9) scheme, the most recent and diffused one.

Table 3. Fryer's scheme of discourse organization in research scientific papers

	Introduction - ***to present the study in relation to previous research***
1.	*Presentation of study background*
	a. established knowledge;
2.	*Identification of gap(s) in existing research*
	a. lack of data (or questionable data) in specific area related to established field;
	b. reason for need to fill the gap;
3.	*Statement of research purpose*
	a. hypothesis/objective;
	b. brief description of material/methodology;
	Methods – *to describe the selection of study material and to recount procedure and techniques used to analyse material*
4.	*Description of material/participants*

	a. size of study sample;
	b. study period;
	c. selection criteria;
	d. type of data collection;
	e. frequency of data collection;
	f. study approval/informed consent;
5.	*Description of experimental procedure*
	a. measurements taken;
	b. defintion of terms;
	c. sample categorisation;
	d. endpoints/outcomes;
6.	*Description of data analysis procedure*
	a. statistical test techniques;
	b. software;
	Results – *to report data obtained in relation to methodology*
7.	*Report of observations*
	a. reference to non-verbal material;
	b. main findings;
	c. associations/correlations (and/or lack thereof);
	d. adjustments to analysis;
	Discussion – *to interpret results in relation to previous research, to discuss implications of study, and to propose areas for further research*
8.	*Discussion of main findings*
	a. findings in relation to hypotehsis/objective;
	b. comparison with literature;
	c. possible mechanisms/causes, implications;
9.	*Study limitations*
	a. strenghts/weaknesses
10.	*Conclusions*
	a. main findings
	b. implications
	c. recommendations/suggestions for future research

Generally, medical research papers start with background information, followed by the lack of data in established knowledge. The author must clearly formulate the goal of the research in a sentence, usually placed at the end of the *Introduction*. The following *Methods* section is rigidly structured: it starts with the description of the materials used and participants recruited; afterwards, it explains in detail the selected methods of investigation, and finally it ends with the analysis of the statistical tests performed. The *Results* section contains a single move, while the *Discussion* is more articulated, since it compares the obtained results to the previous literature in the field and to the purposes of the study. In this section the author may use a more subjective writing style, by highlighting, for example, unexpected and original findings. After that, he/she can optionally decide whether to mention the points of strength

and weakness of the study; the last section, dedicated to the *Conclusions*, may contain indications about study limitations too. Scientific papers always end with a final move, where the author summarizes the results and gives suggestions for further improvements.

These structural rhetorical moves do not find a perfect match in popularized medical articles, thus supporting our thesis that a research papers and a popularization are two different identifiable genres. As a matter of fact, a typical popular science article involves the following sections (cf. Table 4.)

Table 4. Rhetorical moves for discourse organization in popular scientific articles

X	Headline – used to summarise the most important and attractive information
M1	Announcement of recent research findings
M2	Presenting background information
M3	Reviewing previous related research
M4	Presenting new research
M5	Presenting research results quite in detail
M6	Describing data collection and processing
M7	Highlighting main outcomes
M8	Stating research conclusions
M9	Indication of the original source article

As described in Table 4, the headline of the article is fundamental, since it is a key element for catching the reader's attention, however it cannot be considered as a proper rhetorical move. It is followed by the immediate announcement of the main findings of the research later described. Popular articles seem to have an inverted order of the included sections, since they start with the presentation of the results and outcomes, which is the opposite of what happens in research papers. It depends probably on the need to keep the readers' attention high, which is in line with news texts. Impressive results are a great stimulus for the readers, who are probably curious about what steps forward science is making and what implications they will have in their life.

Afterwards, previous knowledge and research on the topic are optionally broadly presented to the reader to substantiate the relevance of the study described; the presence of this information depends on the degree of popularization of the article and its typical target audience.

Moves 4 and 5 introduce more in detail the content of the new research, often alluding to the researchers involved in it, and in some cases to the original research paper.

Going on to move 6, we find the discussion of data collection and processing. This partly overlaps with the first two moves included in research scientific papers, referred to the adopted methods (i.e. description of material/participants and description of experimental procedure).[3] However, in popularized articles such details are omitted, because they address a public of non-experts. Nevertheless, even if at a superficial level, methodological

[3] Cf. Table 3.

information is almost always provided to the reader. This is probably due to the fact that the description of a rigorous methodology behind the study makes it more reliable in the eyes of the reader. The next move, referred to as the *conclusions*, is a major one, since it guides the reader in the interpretation of the data resulting from the research. The authors usually reflect on the outcomes and insert comments and comparisons with previous results of other studies. This move may also include indications for further directions in this research domain. In this move the writers usually use a more subjective style, since they try to solicit the reader's expectations in relation to the topic of the research.

The last move, related to the indication of the original source article, is an infrequent one. This probably depends on the belief that the information given in the popularized article is extensive enough to satisfy the target public.

2.2.2 Differences at a Micro-Structure Level

The main difference that emerges between popularized articles and research papers at a micro-structure level concerns the choice of a different register and vocabulary. Popularized articles select a much less or no specialized lexicon with respect to research papers, since it allows a reorganization of the original text. This process is mandatory, since the target public is varied and specialized lexicon would be an insurmountable hurdle for non-expert readers. The selection of a more common lexicon often makes the process of reorganization of the text coincident with that of its simplification, which makes it comprehensible and relevant to an audience of non-experts (Brand 2008).

It is worth noting that languages for special purposes tend to lose over time some of their features in favour of common language (Cortellazzo 1994), and that, as a consequence, the language of popular science adopts a more informal register in order to reach a wider audience (Gualdo and Telve 2011). Moreover, popularized texts tend to be more prolix and redundant, and show a lower lexical density and a higher preference for a more expositive rather than argumentative style (Garzone 2006).

Another fundamental characteristic of popularization is the tendency to clarify concepts, notions and the meaning of the most specialized terms (Garzone 2006). Below is a list of the most frequent linguistic strategies adopted in popularized medical texts (Calsamiglia and van Dijk's 2004; Myers 1994):

- substituting a specialized term with a general word belonging to the common language, which has an almost equivalent meaning. As an example, the denomination of the active ingredient *salicylic acid* can be replaced by the name of the most common medicine made with it, i.e. *aspirin*;
- paraphrasing or reformulating a term with an explanatory sentence, that should help the reader in understanding a sectorial meaning which is probably unknown. As an example, the term *hematuria* is replaced by the expression *presence of blood in the urine*;

- providing a definition, by replacing a term with a short description of some of its most salient properties. As an example: *hemodialysis, that is a procedure to purify the blood through an external machine*;
- using a metaphor or an analogy to bring a medical concept closer to the readers' everyday life and make it more understandable for them. As an example, *DNA* is often compared to *a book where the code of life is written*;
- developing generalizations: in this case a specialized term is introduced by a statement, which broadens the horizons of its meaning, moving from a specific to a more general concept, as in the following sentence: *generally, a crucial predictor of cluster headache, widespread in most patients, is osmophobia, a psychological hypersensitivity to perfumes or smells*;
- making exemplifications: this process takes place when: "A term is introduced with the help of one or more propositions that exemplify the meaning from a general to an individual concept that exists in ordinary life" (Brand 2008: 38). As an example: *Probably the best-known and most consumed antioxidant is turmeric*.

Some of these criteria have been adopted in this study, to perform the qualitative genre analysis (see Sections 3.1−3.5).

Besides these strategies, Manfredi (2014) analyzes the use of rhetorical figures in popularizations, concluding that metaphors fulfill the main functions of those texts: that of transmitting specialized knowledge to nonspecialist readers, and that of catching the readers' attention.

According to these considerations, in this study we aim to verify, through a qualitative linguistic analysis, lexical and textual evidence that express the recontextualization of the original scientific text during the popularization process, thus contributing to the development of another distinct genre.

In order to conduct this qualitative analysis, two texts have been selected, a research paper and its popularization, focusing on their structural, lexical and rhetorical traits.

The examples given in the next section to describe and discuss the results of this fine-grained analysis, contain extracts from the texts under scrutiny. When these examples come from the popularization written in Italian, the translation in English is provided under the original text. Italics is used to identify the original text with respect to its translation. Emphasis on a particular portion of the text is given, both in the original one and in its translation, through underlined words or phrases.

3. A Qualitative Comparative Analysis Between a Research Paper and a Related Popularized Text

In this section, we describe a one-to-one comparison between the research article *Gallium disrupts bacterial iron metabolism and has therapeutic effects in mice and humans with lung*

infections and its related popularization *Un pasto avvelenato per i superbatteri resistenti agli antibiotici* ('A poisoned meal for antibiotic-resistant superbacteria').

The adopted approach draws mainly from discourse analysis and critical discourse analysis (Fairclough 1992). The Results of our analysis demonstrate that the tendency in popular newspaper articles to disseminate specialized knowledge to the laypublic determines the development of an independent textual genre. It is not a sort of knowledge distortion, nor an adaptation, but rather a proper genre, with its own constitutive features, both at a microlevel (sentence structure, lexicon selected, metaphors used, etc.) and at a macrolevel (structure of the sections included, rhetorical moves used to shape these sections, etc.). Thus, the dissemination of specialized knowledge to the laypublic requires some changes like reformulating vocabulary, reshaping texts, and reorganizing information into a less formal style. The popularization of medical research papers covers several aspects, which are described in detail in the next Sections. Examples are taken directly from the two texts under scrutiny.

3.1 Definition

The practice of defining terms and concepts does not find ample space in research articles, since the authors assume that the reader shares most of the knowledge referred to. Thus, it would be redundant to specify something that is already taken for granted (Gotti 2005). Definition in specialized texts is usually employed when a new specialized term is coined, or when a technical meaning is associated with a word coming from the common vocabulary of a language (Gotti 2005). In popularizations definitions are occasional, since the scarce use of specialized terms does not require such lexical insights. However, when selected, a specialized term is followed by its periphrasis or explanation, with the two separated by a dash or a comma:

(1) *I ricercatori hanno allora pensato di nutrirli con gallio (31Ga), un metallo chimicamente affine al ferro […],*

Researchers then thought of feeding them with gallium (31Ga), a metal chemically similar to iron,

Sometimes, the term to be defined is written in italics, to give it greater visibility, and followed by its definition. In (2) the underlined terms correspond to those written in italics in the original texts:

(2) *[…] si sono concentrati sul batterio Pseudomonas aeruginosa, che infetta polmoni, ferite e vie urinarie […]*

[…] they focused on the bacterium *Pseudomonas aeruginosa*, which infects lungs, wounds and urinary tract […]

As the popular article investigated in this study is published online, the explanation can also be provided by inserting a hypertext link corresponding to the term or the concept to be defined. In (3) the underlined phrase corresponds to this hypertext link:

(3) *Cercare molecole capaci di aggredire dall'interno questi patogeni, impedendone le aggregazioni in biofilm, è sempre più difficile.*

Looking for molecules capable of attacking these pathogens from within, preventing them from aggregating into biofilms, is increasingly difficult.

All the terms and concepts included in (1), (2) and (3) are only mentioned in the research article, but never discussed or defined.

In a popularized text, there may be the repetition of a brief explanation of some technical terms, each time they appear in it; this strategy reveals the writer's awareness that the reader is probably not an expert in the field.

3.2 Denomination

In specialized texts, acronyms and other similar abbreviations are often used with a naming function (Mattiello 2013), since they are highly monoreferential inside a specific subject (Gotti 2005). In these contexts, abbreviations are efficient labels that allow a fast transmission of the information and avoid redundancy. Therefore, they are often preferred over their full-form referents. In (4a), (4b) and (4c), some of the acronyms used in the investigated research paper are mentioned:

(4) a. *pvdA-gfp* (a DNA transcriptional regulator)

b. *CF* (cystic fibrosis)

c. *SOD activity* (superoxyde activity)

In the popularized text, the author tends to use the extended forms of these terms, thus taking into account the level of knowledge assumed for the target public. As an example, the acronym *CF* always occurs in its extended version, *cystic fibrosis*, thus making it clearer for the reader.

Denomination is a relevant aspect in popularized texts too (Calsamiglia and van Dijk 2004), where it is possible to find abbreviations linked to well-known or lexicalized acronyms. This is due to the fact that some of these labels are also familiar for non-expert readers. In (5) and (6) the acronyms AIDS and DNA are used in the popular article without any explanation, since they are so largely diffused and well-known by the large public, that they have lost their status of specialized labels:

(5) *[…] difficile da debellare per i pazienti già affetti da altre condizioni, come fibrosi cistica, cancro o AIDS.*

[…] difficult to eradicate for patients already suffering from other conditions, such as cystic fibrosis, cancer or AIDS.

(6) *Questa sostanza distrugge infatti gli strumenti molecolari che i batteri impiegano per produrre nuovo DNA,* […]

In fact, this substance destroys the molecular tools that bacteria use to produce new DNA,

[…]

3.3 Accuracy and Validation

In medical research articles, data is commented on with high precision, figures are accurately reported, sources are explicitly specified and incorporated in the text either by using direct quotation or by paraphrasing other authors' ideas and sentences (Swales and Feak 2012). This attention gives reliability to the content of the specialized text and helps the authors to support their ideas and procedures. We do not find the same precision in popularized articles, which are more approximate.

(7) *Nello studio pubblicato su Science Translational Medicine, Pradeep Singh e Christopher Goss riportano che si sono concentrati sul batterio Pseudomonas aeruginosa […]*

In the study published in Science Translational Medicine, Pradeep Singh and Christopher Goss report that they focused on the bacterium Pseudomonas aeruginosa […]

In (7), the author of the popularized article refers to the journal where the original study was published, but neither the title of the study nor the year of publication appear. Moreover, only two out of the twenty-one authors who wrote the article are mentioned.

Conversely, the research paper provides all these indications with great precision, as a sign of accuracy and reliability within the academic community. It includes a large amount of references and notes, mentioning other scholars and studies that influenced the research or that have prepared the ground for its realization, as evidenced by the presence of 52 bibliographical references.

Furthermore, many figures are used to illustrate methodological steps and statistical results. Each of them is complemented by a detailed caption, describing its content and function within the article, as illustrated in (Fig. 1).

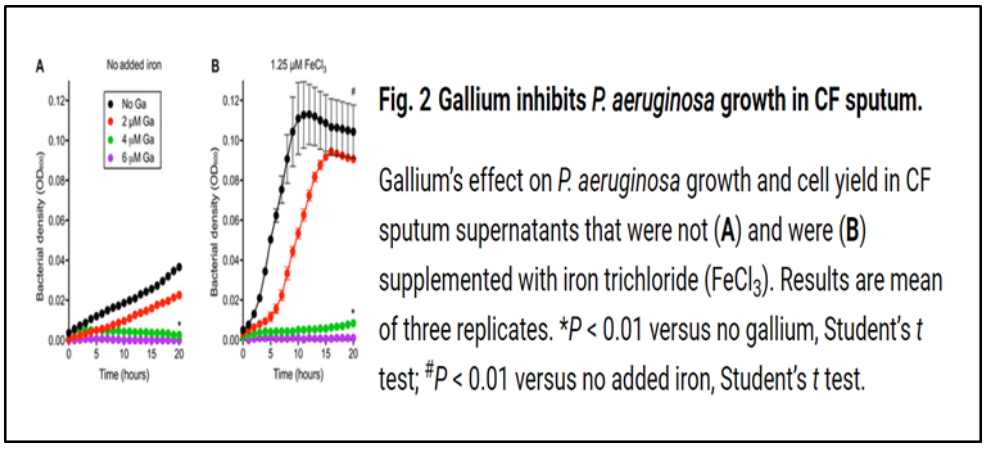

Figure 1. An example of figures and captions in the research paper

3.4 Description

Scientists typically elaborate descriptions to illustrate the methodology used in their research, or to explain how data have been collected and further processed (Swales and Feak 2012). By doing so, they aim to use a neutral and objective style, as in (8).

(8) *The objectives of this work were to test gallium as a potential antibacterial treatment for people with CF and chronic P. aeruginosa lung infections. We used* in vitro *experiments to investigate* $Ga(NO_3)_3$ *mechanism of action, gallium resistance, the combined activity of gallium with antibiotics, and gallium's effect on macrophage activity. We also tested gallium in mice infected with P. aeruginosa and in people with CF and chronic P. aeruginosa lung infections in a nonrandomized phase 1 clinical trial […]*

On the other hand, journalists, who are usually the authors of popularized texts, use descriptions to emphasize situations or conditions, to show their gravity and to catch readers' attention. The most adopted technique in this textual genre is exaggeration, as illustrated in the following example:

(9) *L'ultima strategia proposta nella lotta ai superbatteri resistenti agli antibiotici, prevede di colpirli nel piatto in cui mangiano.*

[…] Durante le infezioni i superbatteri come questo hanno bisogno di ferro (26Fe) per nutrirsi e replicarsi, e lo sottraggono all'organismo ospite con ogni sorta di stratagemma. I ricercatori hanno allora pensato di nutrirli con gallio (31Ga), un metallo chimicamente affine al ferro che, tuttavia, non solo non è "nutriente", ma è anche dannoso.

The last strategy proposed in the fight against antibiotic resistant superbugs is to target them on the plate they eat.

[...] During infections, superbugs like this need iron (26Fe) to feed and replicate, and take it away from the host organism using all sorts of stratagems. The researchers then thought of feeding them with gallium (31Ga), a metal chemically similar to iron, which, however, is not only not "nutritious", but is also harmful.

Metaphor is another technique used in popularizations to exaggerate the content of the text, especially when this comparison sounds unusual or absurd, as it does in (10), where gallium is compared to a Trojan horse, able to mask itself as a nutrient for the bacteria, and to reveal only at a later stage its dangerousness:

(10) *[…] una sostanza che somiglia al loro cibo, ma che una volta ingerita si rivela per quello che è: un cavallo di Troia capace di distruggerli e impedirne la replicazione.*

[...] a substance that resembles their food, but that once ingested reveals itself for what it is: a Trojan horse capable of destroying them and preventing their replication.

3.5 Metaphor

Metaphors play a central role in building a bridge between popular and scientific knowledge. We have investigated in this study what metaphors are used when communicating to the larger public information taken from biomolecular-medicine (bacteria, molecules and related terms), and what images are produced. The results show that this field is rich in metaphors

and such resources play an important role when recontextualizing knowledge from one domain to the other.

Anthropomorphic metaphors are frequent in popularized texts and so bacteria become intentional agents that can be, for example, deceived or enticed, as illustrated in (11) as well as (9) above. Even war metaphors occupy a large space in popularizations, recalling the image of the disease as a fight for health, where pathogenic agents are the enemy to be defeated, as in (12).

The extensive use of metaphors in popularized texts testifies to the role of specific cultural categories when narrating abstract phenomena.

(11) a. *Prendili per la gola e poi... annientali!*

Take them by the throat and then ... annihilate them!

b. *Così due ricercatori dell'Università di Washington hanno provato a ingolosire i batteri.*

So, two researchers at the University of Washington tried to pull the bacteria's strings.

(12) *Contro un nemico che sembra adattarsi ad ogni nostra mossa, occorre pensare fuori dagli schemi: l'ultima strategia proposta nella lotta ai superbatteri resistenti agli antibiotici, prevede di colpirli... nel piatto in cui mangiano.*

Against an enemy that seems to adapt to our every move, we need to think outside the box: the last strategy proposed in the fight against antibiotic resistant superbacteria, plans to hit them... on the plate on which they eat.

In (11) and (12) the concrete and familiar categories of *food* and *struggle* are used to illustrate the more abstract and specialized mechanisms underlying the bio-chemical action of the experimental antibiotics. This stylistic choice allows the reader to understand, even if at a superficial level, the content of the experiments conducted by the scientists in a very specific domain.

3.6 Lexicon and Terminology

In official medical discourse, the vocabulary used comes from the relative jargon and commonly includes: specialized terminology, technical expressions, latinisms and professional language, which are accessible only to the experts in the sector. By contrast, in popularizations, writers tend to flank specialized terms with idiomatic expressions, informal language and even slang (Mattiello 2008). In (13), for example, an idiom is used in the popular text of reference:

(13) *Prenderli per la gola*

To tempt their tastebuds

The excerpt in (14), instead, provides an example of the usage of a common word used with a particular meaning:

(14) *Non solo non è "nutriente", ma è anche dannoso […]*

Not only is it not "nourishing", it is also harmful [...]

Nourishing is an adjective that in Italian refers to the properties of what is eaten by human beings; it is unusual to see it used for microorganisms, like bacteria. In this case, these latter are seen as direct enemies of men, and then therefore undergo an anthropomorphization process.

3.7 Rhetorical Moves

As illustrated in Section 2.2.1, different types of texts show a different organization of their structure. We base our analysis of the sections constituting the research paper and popularized article of reference on the previous works of Nwogu (1997), Fryers (2012) and Swales (1990) on the so-called *rhetorical moves*. These correspond to different parts of the text, each with its proper function and content.

Having already illustrated in Section 2.2.1 the different rhetorical moves belonging to these two distinct textual genres, we will analyze here the main differences observed, by providing examples from our text sources.

First of all, the shift from the research genre to the popularized one overturns the IMRD (Introduction-Methods-Results-Discussion) structure, thus moving from an inductive system to a deductive one. Research papers move from the particular (i.e. the realized experiments) to the general aspects (usually the theory underlying the research hypothesis). Popularized articles instead follow the reverse path; they open with the explanation of the background theory to the layreader, who is probably not informed about the discussed topic, to justify the development of the further described experiments. In the popular article under scrutiny, we find the exact reproduction of this process: the article starts with the presentation of the state of the art,

(15) *Contro un nemico che sembra adattarsi ad ogni nostra mossa, occorre pensare fuori dagli schemi: l'ultima strategia proposta nella lotta ai superbatteri resistenti agli antibiotici, prevede di colpirli... nel piatto in cui mangiano.*

Against an enemy that seems to adapt to our every move, we need to think outside the box: the latest strategy proposed in the fight against antibiotic resistant superbacteria, plans to hit them ... on the plate on which they eat.

then it continues by illustrating the research assumption of the scholars:

(16) *UNA STRADA DIVERSA. Cercare molecole capaci di aggredire dall'interno questi patogeni, impedendone le aggregazioni in biofilm, è sempre più difficile. Così due ricercatori dell'Università di Washington hanno provato a ingolosire i batteri con una sostanza che somiglia al loro cibo, ma che una volta ingerita si rivela per quello che è: un cavallo di Troia capace di distruggerli e impedirne la replicazione.*

A DIFFERENT ROAD. Looking for molecules capable of attacking these pathogens from within, preventing them from aggregating into biofilms, is increasingly difficult. So, two

researchers at the University of Washington have tried to bite the bacteria with a substance that resembles their food, but that once ingested reveals itself for what it is: a Trojan horse capable of destroying and preventing replication.

and concludes with a superficial description of the experimental procedures adopted,

(17) *Durante le infezioni i superbatteri come questo hanno bisogno di ferro (26Fe) per nutrirsi e replicarsi, e lo sottraggono all'organismo ospite con ogni sorta di stratagemma. I ricercatori hanno allora pensato di nutrirli con gallio (31Ga), un metallo chimicamente affine al ferro che, tuttavia, non solo non è "nutriente", ma è anche dannoso. Questa sostanza distrugge infatti gli strumenti molecolari che i batteri impiegano per produrre nuovo DNA, e quindi per replicarsi. Senza nuovo codice genetico, i patogeni non possono moltiplicarsi, e l'infezione è debellata.*

During infections, superbacteria like this need iron (26Fe) to feed and replicate, and take it away from the host organism using all sorts of stratagems. The researchers then thought of feeding them with gallium (31Ga), a metal chemically similar to iron, which, however, is not only not “nutritious”, but is also harmful. In fact, this substance destroys the molecular tools that bacteria use to produce new DNA, and therefore to replicate. Without a new genetic code, pathogens cannot multiply, and the infection is eradicated.

Another difference between the two genres concerns their opening moves, particularly the first move that introduces the rest of the text. In the research paper under scrutiny this includes *background information*, as in (18), whereas in the popular article it contains the *announcement of the main outcomes*, as in (19).

(18) *Previous work by others and us found that gallium compounds had antibacterial activity against a number of human pathogens including Pseudomonas aeruginosa (11), Francisella tulerensis (12), Acinetobacter baumannii (13), several mycobacterial species (14, 15), Klebsiella pneumoniae (16, 17), and other important pathogens (18–20). Work with P. aeruginosa showed that gallium was effective against bacteria grown as biofilms, in stationary-phase cultures, and against multidrug-resistant CF clinical isolates.*

(19) *Prendili per la gola e poi... annientali! In studi su uomini e topi, i patogeni hanno confuso un metallo (il gallio) con il ferro di cui si nutrono. Ma la sostanza, ingerita, si comporta come un cavallo di Troia*.

Tempt their tastebuds and then ... annihilate them! In studies of humans and mice, pathogens have confused a metal (gallium) with the iron they eat. But the substance, ingested, behaves like a Trojan horse.

The layreaders are not so interested in deepening their knowledge of previous works done in the field, they straight away want to know whether the content of the article is relevant to them. That is why journalists start with a captivating announcement. On the contrary, researchers have to rely on previous renowned studies to demonstrate the validity of their ideas and procedures.

Moving through the subsequent rhetorical moves, we meet another difference, that is, a

qualitative one. In fact, the section dedicated to the *description of data collection methods* and *procedures of experimentation* is included in both texts, though at a different level. In the research paper they occupy ample space (six pages out of twelve), whereas in the popular article they are summarized in one paragraph.

Methods, data and procedures of analysis are of great relevance to a community of specialists, in order to evaluate the precision and accuracy of their studies; laypeople, who do not have the competences for judging similar parameters, are faced with optional and redundant pieces of information in popularized texts.

The section dedicated to the presentation and discussion of the results undergoes a similar treatment. The findings in the research paper are described with an in-depth analysis, therefore each of them occupies a single section introduced by a heading written in bold. This highlights the wide scope of a scientific experiment and all possible implications for future research. The popularized article, instead, focuses on the general results of a study, never going into detail in depth. What layreaders need to know is how the outcomes of a scientific study may affect their life. Hence, a popularized article provides an emphatic description of the benefits of a discovery rather than an objective description of the results..

Summing up, we can conclude that a research article and a popularized medical text differ in three aspects: first, they show a different textual organization with a different collocation of the included rhetorical moves throughout the text; second, there is a quantitative difference in the number of rhetorical moves contained in the two different types of texts. Some sections, for instance *statistical methods* and *study limitations*, are typical of research papers but are excluded from popularized articles, due to the different function and audience. Third, the difference is of a qualitative nature and refers to those moves identifiable in both textual genres though developed at a different level. Usually, research papers are defined by an in-depth analysis of the topic treated in the different sections, whereas popularized articles provide information at a shallower level.

4. Discussion and Conclusions

Medical research papers and popularizations can be said to be the two sides of the same coin; for decades, popularization has been seen as a process of mere simplification or, even worse, a distortion of the original text of reference.

The current vision tends to define popularization as a different way of interpreting the discoveries of medical science for different audiences. In comparing academic and popular medical science discourse, research is motivated by the specific needs of both experts and layreaders, who produce or interpret texts belonging to these genres. We use the term *genre* in the plural because we intend research papers and popular scientific texts as two distinct textual genres, rather than the latter being the adaptation of the former.

In order to substantiate our claim, we performed a qualitative comparative one-to-one analysis. The texts under scrutiny were: a research paper published in *Science Translational Medicine*, addressed to a public of experts in the field or scholars, and a popular article published in *Focus*, an Italian magazine dedicated to the dissemination of scientific

knowledge to the laypublic. They deal with the same topic, a biomedical discovery made by a team of American researchers, who tested the use of gallium instead of iron in a particular group of bacteria.

Our analysis developed at a double level: a macrostructural one, which referred to the order and content of the different sections included in the two mentioned genres. This kind of analysis is based on the pioneering works of Swales (1981), Nwogu (1997) and Fryer (2007, 2012), taking into account the distinct rhetorical moves typical of the different categories of texts. While research papers follow a rigid IMRD (*Introduction-Methods-Results-Discussion*) structure, comprising ten different moves, popularized articles show a set of nine moves, some of them overlapping with the first one. However, relevant differences exist across the textual organization of the two genres. The medical research paper under scrutiny starts with the *background information*, whereas its popularization opens with the *announcement of the main outcomes*. This is a sort of deductive scheme, useful in capturing layreaders' attention, which is one of the main goals of popularized texts. Another difference concerns the *review of previous research* and the *identification of gaps in established knowledge*, which is a more rigid move in medical research papers than in popular texts. The moves regarding *data collection methods* and *procedures of experimentation* are identifiable in both genres, but they are more detailed in the research article, since they convey reliability to a scientific study and act as a guide for the other experts to follow the phases of the research. Laypeople instead, do not have the need and the required background to make such a thorough analysis of the topic; on the contrary, they require a general overview of the steps performed to develop the study, and a more detailed explanation of the findings in relation to the expectations and impact on their daily lives. For the same reasons, *statistical methods* and *study limitations* are not typical components of popularized articles, while they are fixed elements in research papers. The move *conclusions* belongs to both textual genres and its position is regularly established at the end of the texts under scrutiny.

In addition to a different text structure, research papers and popularizations also show a different use of some microtextual components, mainly operating at a lexical level. Among these we mention: the selection of lexicon, the use of metaphors, the elaboration of definitions, descriptions, denominations, etc. Our analysis revealed that popularized texts try to avoid the use of specialized terminology, preferring a more familiar lexicon for the reader. Similarly, the use of acronyms is not recommended in this type of text, since they could be problematic for the target reader. Highly diffused acronyms, such as DNA, are exceptions and are frequent in both types of texts, since they are commonly used both by experts and laypeople. Processes like that of *definition* are rare in research papers, where the author supposes a common shared knowledge with the other members of the scientific community and therefore considers as superfluous the definition of terms and concepts that should already be taken for granted. Accuracy in providing references, detailed data and other specialized information is more evident in research papers, where this kind of information is quite mandatory, since it provides validation to the findings of the study. Popular articles, instead, do not need this kind of attestation, since they are based on already verified studies, made by renowned experts in the field. Rather, they must be as attractive and impressive as

possible, in order to catch and maintain the layreader's attention.

In conclusion, we can state that the outcomes of our analysis support our initial assumption concerning the existence of two separate textual genres, with different structures and different subcomponents (lexicon, rhetorical figures, etc.). This mainly depends on the function of the text and the target public to whom it is addressed.

In order to reinforce these results, and give a more solid attestation to our claim, we envisage in the future the possibility of performing a quantitative analysis on this topic, by creating *ad hoc* a large corpus of texts.

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