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Constructing social representations of science and technology: the role of metaphors in the press and the popular scientific magazines

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This paper aims to reveal the social representations about the nature and the evolution of Space-Science & Astronomy, Genetics & Biotechnology, Natural Sciences and Engineering & Informatics, through analyzing active (i.e., original and creative) metaphors found in 2303 technoscientific articles published in four Greek daily newspapers and two popular scientific magazines. The analysis showed that all metaphors concerning the nature of the four disciplinary fields can be clustered into four superordinate categories that juxtapose these fields to: (1) a construct; (2) a supernatural process; (3) an activity extending the frontiers of knowledge; (4) a dipole of promise and/or scare. The most frequently employed category is that representing technoscience as an activity extending the frontiers of knowledge. Furthermore, the evolution of the four disciplines is mainly represented as a violent process. Each discipline though, seems to be characterized by combinations of different categories of metaphors. Therefore each discipline evokes different social representations.

1. Introduction

One of the most important aspects of public understanding of science and technology (S&T) refers to one's understanding of the social practices and organization of these two areas and how scientists and engineers collect, interpret, and use data to direct further research and construct technological artifacts (Miller, 1983; Shapin, 1992; Bauer and Schoon, 1993; Yearley, 1994; Driver et al., 1996). Another aspect of public understanding of S&T believed to be important regards the values and assumptions inherent to the development of scientific and technological knowledge (Lederman and Zeidler, 1987).

However, a number of international studies have shown that the general public has low levels of awareness of the epistemology and sociology of S&T (Lederman, 1992; Bauer and Schoon, 1993; Miller, 1998; Miller, 2000; Eurobarometer 55.2, 2001). Nevertheless, the general public has the chance to form a wealth of fragmented opinions about S&T from a large variety of mediated views put forward by various social actors, such as the mass media, industry, and regulatory bodies in the public arena.

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These fragmented views combined may give rise to coherent frameworks within which all the subsequent encounters of a layperson with S&T can be interpreted and assimilated. Such frameworks correspond to the notion of social representations, which are defined by Moscovici as general classes of ideas and beliefs that are used collectively as explanatory devices to establish a social order, and to enable individuals to orientate themselves in their material and social world and to make meaning of it (Moscovici, 1984). The purpose of all social representations is to make familiar the unfamiliar, enabling it to be assimilated as part of the common-sense knowledge. So the diffusion of technoscientific knowledge within the general public, through its transformation to social representations, creates a "second-hand commonsense" (Moscovici, 1984).

The generation of public representations of S&T involves the classification and conceptualization of an unfamiliar phenomenon (i.e., the technoscientific endeavor) into a set of well-known categories. This process can be effectively accomplished with the use of metaphors, which constitute an important and pervasive form of figurative speech, basic to language and cognition, in order to structure human experience (Lakoff and Johnson, 1980; Gamson and Modigliani, 1989; Vosniadou and Ortony, 1989; Katz, 1998; Goatly, 2000).

According to Lakoff and Johnson (1980) metaphors facilitate thought by providing an experiential framework within which abstract thoughts can be accommodated. The metaphoric schema grounds the conceptual structures of an abstract domain (target) to a physical one (source). Since metaphor involves a transfer of concepts from a specific context to another context, the transferred, familiar concepts interact with the new unfamiliar context, highlighting it and producing effects in terms of potential shifts in meaning (Hesse, 1996; Holton, 1998).

Thus, metaphors provide perspectives on how knowledge is to be organized and perceived. They act as illustrative devices, and in this sense they provide a significant key to model-building in every aspect of cognition (scientific thought included). They provide agendas for the new awareness of knowledge systems and create formulas for the programmed exploration of data. Metaphoric language becomes a part of the social and cultural contexts of communication and plays a major role in the legitimation of social values. In conclusion, metaphors are not only innovative creative tools of thought, they also play an important role in the social construction of reality (St Clair, 2002).

Metaphor as a tool of theory building and popularization of science

Scientific ideas evolve through a continuous process of circulation and communication, especially within the scientific community. Science and scientific evolution are often metaphorically described, and metaphors used for this purpose may reflect different epistemological positions. Powerful epistemological metaphors are, for example, the view of physics as the "queen," or epitome of the natural sciences, or the Kuhnian metaphor of "scientific revolution" evoking the idea of a theory shift within the scientific community (Maasen and Weingart, 2000). Furthermore, metaphors pervade scientific discourse, in the process of modeling reality. For instance, in order to describe light, physics introduces two alternative metaphors, wave and particle. Also, a text on chaos theory will probably contain metaphorical terms such as the arrow of time, communication among molecules, or free particles (Goatly, 2000).

According to Brown, all knowledge is perspectival, i.e., theories are themselves merely metaphors, ways of looking at things. They are merely epistemological tools, attempts at understanding reality. Therefore, the key to understanding science (as any other culture) involves an understanding of its metaphorical worlds (Brown, 1977).

On the other hand, the production of social representations occurs within and among various discursive sites. While scientific (metaphoric) discourse is formed and preserved for specific purposes within the scientific community, it is linked to all other discourses, e.g., political, literary, or technological ones, since science is part of the overall cultural system. If the focus is on the production of meaning across the boundaries of S&T and society (through the media, for instance), then metaphor is a "unit of circulation" of knowledge between those different discourses. Thus, the analysis of metaphors in popularized science texts aims at identifying the ways in which the journey of individual terms and concepts outside their primary context gradually produces (heterogeneous sets of) social representations of S&T for a period of time.[1]

Popular scientific texts are certainly a place that social representations of S&T are to be found (Farr, 1993; Gaskell, 1999). Since metaphors as described earlier play a central role in the formation of social representations of S&T, the objective of this paper is to explore such representations evoked by the use of relevant metaphors in two of the most important and influential kinds of popular scientific texts, those of daily press articles and articles of popular scientific magazines.[2]

Similar efforts have also been undertaken by other researchers in the past (Bucchi, 1998; Nelkin, 1994; Nelkin and Lindee, 1995; Liakopoulos, 2002; Wagner et al., 2002). These efforts, though, either concentrated on the social representations of a specific scientific discipline (usually biotechnology) or focused on only one evoked type of representation (e.g., science as cookery). Drawing on these previous studies, this paper sets out to isolate the most prominent social representations evoked by the use of metaphors in the daily press and the popular scientific magazines about the nature of S&T, in general, as well as for four specific technoscientific disciplines: Genetics & Biotechnology, Natural Sciences (Physics, Chemistry, Geology and Meteorology), Space Science & Astronomy and Engineering & Informatics. These four disciplines are the most publicly visible ones, since according to one recent study their overall press coverage accounts for almost the totality of the press content on technoscientific issues (Dimopoulos and Koulaidis, 2002).

2. Method

The sample analyzed consisted of 2303 articles referring to the four techno-scientific disciplines examined in this paper (i.e., Space Science & Astronomy, Genetics & Biotechnology, Natural Sciences and Engineering & Informatics) and published in four major Greek newspapers (*Vima*, *Eleftherotypia*, *Eleftheros Typos*, and *Kathimerini*) and in two of the most widely circulating popular scientific magazines in Greece (*Focus* and *Georama-Experiment*).[3] Specifically, the criteria we reached for selecting an article as relevant to our study were: (1) a clear focus on issues related to the four aforementioned technoscientific disciplines; (2) the use of experts in these disciplines as sources; (3) the use of specialized terminology (e.g., genes, comets, viruses, point of fracture, chemical equilibrium, etc.) or of specialized graphical representations (e.g., a graph representing the structure of DNA).

The newspaper articles were sampled using the method of four "constructed weeks" per year, over a 3-year period extending from January 1996 to December 1998 (Hansen et al., 1998). On the other hand, the articles from the popular scientific magazines cover the period of 1999 to 2001 for the *Focus* magazine and the period between March 2000 and the end of 2002 for *Georama-Experiment* and were selected following a procedure of random sampling of three to four S&T articles per issue.

The overall scheme for the sample construction is illustrated in Table 1.

Table 1. The scheme of sampling

		No. of articles	Sampling procedure	Period of sampling	Frequency of publication
Newspapers	*Vima*	2133			Weekly
	Elefhterotypia		Constructed week	1996–1998	Daily
	Elefhteros Typos				Daily
	Kathimerini				Daily
Magazines	*Georama*	170	Random sampling of three to four S&T articles per issue	1999–2001	Bimonthly
	Focus			2000–2002	Monthly

S&T, science and technology.

As is apparent in Table 1, all sampled articles were published between the beginning of 1996 and the end of 2002, a time-span of 6 years; this is short enough that cultural constructs, such as social representations which otherwise vary with time, could be considered to remain more or less stable and retrievable from the same pool of images.

The articles of our sample were distributed in the four major technoscientific disciplinary fields of Space Science & Astronomy, Genetics & Biotechnology, Natural Sciences (i.e., Physics, Chemistry, Geology and Meteorology) and Engineering & Informatics (Table 2).

Once the articles in the sample had been collected, they were carefully examined in order to identify all the metaphors concerning the nature as well as the evolution of the four technoscientific fields examined here. Specifically, the metaphors selected were those that involve as a target domain: (1) scientist(s) and engineer(s) (either mentioned in general or by name); (2) scientist(s)' or engineer(s)' personality attributes; (3) scientific and technological methods; (4) corresponding institutions; (5) scientific claims and theories or technological products that can metonymically characterize a whole technoscientific discipline (e.g., theory of general relativity).

All identified metaphors were classified into three categories according to their originality, namely, the dead, the conventional, and the active metaphors. Dead metaphors are those that cannot be distinguished easily (or at all) from literal, ordinary language. In the case of a dead metaphor, both the source and the target domains are indexed as different meanings of the same word or phrase (for instance, the galaxy as a fluid, milk-like substance, from the Greek word γάλα [γala], meaning milk). Conventional metaphors can be readily identified as non-literal statements, but they have been so widely and system-

Table 2. Frequency distribution of the sampled articles by reference to technoscientific disciplines

	Frequency of articles	
Field	*N*	%
Space Science and Astronomy	206	8.9
Genetics & Biotechnology	708	30.8
Natural Sciences	319	13.8
Engineering & Informatics	1070	46.5
Total	2303	

atically used that they retreat to "transparency" by becoming so habitually employed that they are hardly perceived as being metaphors at all (e.g., genetic code). Finally, active metaphors are original in the sense that they can be recognized as "vital," (Black, 1979), since they produce semantic anomaly. Such metaphors (Lakoff and Johnson, 1980) can either belong to the "unused" part of a conventional metaphor (e.g., "a scientific theory with winding corridors," which belongs to the conventional metaphoric schema of "theories as buildings"), or be totally novel (for instance, "Classical theories are patriarchs who father many children, most of whom fight incessantly").

The present analysis was restricted to active metaphors: this kind of metaphor is more likely to lead to new insights and possible representations by introducing strange juxtapositions of referents belonging to different fields and hence being more original than the dead and conventional metaphors, that by having been embedded in the everyday discourse might be easily overlooked by a reader as sources of novel insights.

Following this procedure, from the total of 2303 articles selected initially, only 253 were found containing one or more metaphors regarding S&T. In total, 425 metaphors about S&T were identified in the two media (press and popular scientific articles). In general, the magazine articles were far richer in metaphors than the newspaper articles in terms of the number of articles containing metaphors and in the mean density of metaphors. Specifically, 60.0% of the magazine articles contained relevant metaphors, while the corresponding percentage of the newspaper articles was only 6.9%. Additionally, the mean density of metaphors concerning S&T was 11.45 metaphors per 10,000 words (1.57 metaphors per article) in the magazines, while it barely reached 2.4 metaphors per 10,000 words (0.08 metaphors per article) in the newspapers. However, it is interesting to note that the articles in the specialized techno-scientific columns of the press contained almost double the number of relevant metaphors per article in comparison with the articles in the general columns (0.11 and 0.06 metaphors per article respectively).

The metaphors identified in the press and the popular scientific magazine articles were inductively and retrospectively grouped under common categories of source domains (e.g., game, adventure, religion, biological cycle, etc.). For example, the metaphor "the scientist worked using a palette full of formulas and algorithms" projects the scientific activity to the category of a piece of art that contains many different basic level connotations (creativity, inspiration, skillful handling, expressionism, etc.). Two coders (two of the authors) undertook this reiterative process based on consensus until each metaphor was uniquely ascribed to a source domain category. It is worth noting, however, that a single clause could contain more than one metaphor, often belonging to ontologically different categories. In such cases, each metaphor was independently treated and coded.

These initial categories were further condensed into superordinate categories according to conceptual similarities between different source domains. Such categories cover the most overarching characteristics of metaphors belonging to them. For instance, two metaphors describing science as a piece of art and an artifact belong to the same superordinate category of construct, requiring among other things the purposeful application of specific knowledge and techniques, imagination and originality, as well as the systematic and structured involvement of a skilled person. Likewise, metaphors representing S&T as a journey, a decoding process, and a process of receiving messages through the senses, were grouped together in a superordinate category titled "extending the frontiers of knowledge," while two metaphors representing scientists as playing God and as magicians merge in the superordinate category of the "supernatural." In this way, the superordinate categories created by the intrinsic associations that metaphors evoke, serve as plausible explanatory social representations of S&T.

3. Results

In this section, the frequency of the metaphors disaggregated by technoscientific field (i.e., Space Science & Astronomy, Genetics & Biotechnology, Natural Sciences and Engineering & Informatics) will be presented first. The analysis framework that was developed by grouping the metaphors recorded in the articles will be discussed, illustrated by relevant examples in order to clarify the criteria used for metaphor classification in superordinate categories. Moreover, the frequencies of metaphors per superordinate category will be presented and the relevant tendencies will be explored.

There is a rather uniform distribution of metaphors among the four basic disciplinary fields (Table 3). Metaphors referring to Space Science & Astronomy are the most frequently found (29.4% of the total), closely followed by metaphors on Genetics & Biotechnology (27.5% of the metaphors). Metaphors concerning Engineering & Informatics constitute a further 22.8% of the total of metaphors, while those referring to Natural Sciences reach 20.3%. Moreover, the densities of metaphors vary considerably according to disciplinary field, ranging from 1.8 metaphors per article for Space Science & Astronomy to 0.04 metaphors per article for the technological disciplines of Engineering & Informatics (Table 3). This relatively heavier use of metaphors in the articles referring to Space Science & Astronomy could possibly be explained by the fact that the phenomena and the procedures falling within this discipline are far more exotic and distanced for lay-people's every-day discourse and experience than in the case of any other field, and hence the explanatory power of metaphors is more needed for their presentation.

The metaphors involved in the articles that were analyzed refer either to the nature of S&T or to the evolution of the two domains. From the total of 425 metaphors isolated, 323 (76%) concern the nature of S&T, while the remaining 102 (24%) refer to the evolution of technoscientific knowledge.

This distinction was maintained in the development of the analysis framework, which is illustrated in Figure 1, by means of a systemic network. Thus, the metaphor analysis framework involves two dimensions, namely: (1) the nature of S&T; and (2) the evolution of S&T. These two dimensions of metaphor analysis are discussed in detail in the following sections.

3.1 Metaphor classification

The nature of science and technology

Regarding the nature of S&T, these two domains can be represented as:

(1) a construct the construction of which involves inspiration, originality, imagination and creativity, as well as, skillful or even artistic handlings;

Table 3. Distribution of metaphors by technoscientific discipline

Disciplinary field	*N*	%	Metaphors per article
Space Science & Astronomy	125	29.4	1.80
Genetics & Biotechnology	117	27.5	0.08
Natural Sciences	86	20.3	0.04
Engineering & Informatics	97	22.8	0.18
Total	425	100	0.19

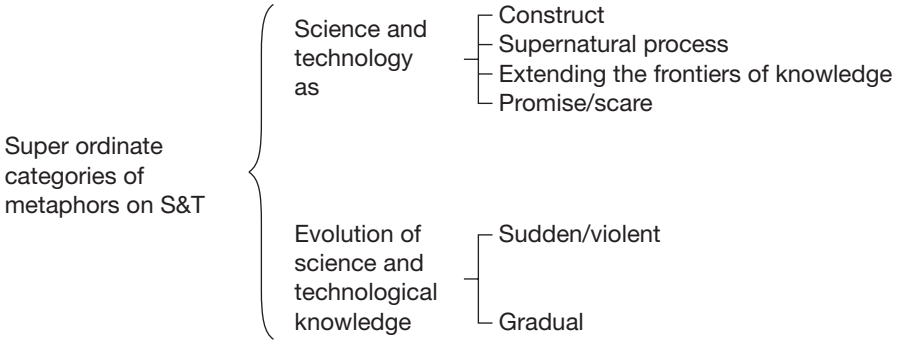

Figure 1. The metaphor analysis framework. S&T, science and technology.

(2) a supernatural process that goes well beyond natural order;
(3) an activity extending the frontiers of knowledge, extending at the same time the mastery of humankind;
(4) a dipole of promise and/or scare mainly due to the applications of these two domains.

Science and technology as a construct. When S&T are represented as related to a construct, they are usually juxtaposed with the following:

- An artifact, e.g., "Newton's Universe was a magnificent and well wound clock . . ." (*Georama*, vol. 39, 2000: 166–91);
- A piece of art, e.g., "Carlo Rubbia is the Pavarotti of elementary particles" (*Kathimerini*, 1/6/1997: 20) or "The new theory is composed by the orchestra consisting of young researchers" (*Vima*, 10/3/1996: 29);
- Cooking, e.g., "Genetic engineering has started cooking long before vegetables reach the housewife's basket" (*Eleftheros Typos*, 18/2/1996: 39); and
- Clothing, e.g., "ATM technology is promoted as the latest model in the collection of the European telecommunication industry fashion show" (*Kathimerini*, 21/6/1997: 18).

Science and technology as a supernatural process. In cases where S&T are represented as related to a supernatural process they are usually linked to the following:

- Religion, e.g., "Be it the greenhouse effect, the China syndrome, nuclear war, or nanorobots, world destruction by the human achievements is nothing but a distorted biblical scene, that of man playing god with the powers of Apocalypse" (*Georama*, vol. 46, 2001: 36–57) or "Biotechnology has become the new religion of the local government" (*Georama*, vol. 45, 2001: 86–91);
- A miracle, trick, or magic, e.g., "Scientists as modern-day witches boil and stir various chemical ingredients" (*Eleftherotypia*, 16/1/1997: 24) or "Even the most magically developed technology cannot develop a material that will be able to exceed the speed of light" (*Focus*, vol. 3, 2000: 16–23).

Science and technology as an activity extending the frontiers of knowledge. A fundamental feature of this representation is the willingness to pass beyond what one knows, exploring new previously unknown territories. As such, S&T constitutes a structuring activity, which provides a sense of order. S&T is also seen as a natural process that serves as an instrument of testing ideas, of imparting special meaning to the daily patterns of life,

of creating new images and manipulating already established ones, of supporting and maintaining representations, and of imposing rules and regulations on the experiential world (St. Clair, 2002). In this metaphoric schema S&T are usually related to the following:

- A mystery resolution (also puzzle-solving, finding something hidden, or police investigation), e.g., "The mystery of the neutron stars was resolved due to L. Franco's research efforts in the University of Chicago which ended up with an unexpected answer" (Focus, vol. 12, 2001: 61–69);
- An exploration of new and unknown lands (or an adventurous expedition), e.g., "Space exploration is a journey to the Ithaca of knowledge. It is possibly an endless journey which may hide a lot of surprises" (*Georama*, vol. 34: 2–51);
- Learning a secret, e.g., "Scientists try to learn the secrets that neutrinos hide" (*Eleftherotypia*, 16/5/1997: 25);
- Extending the potential of the human senses through the use of sensitive instruments, e.g., "The Hubble space telescope directed the astronomers' gaze above the opaque atmosphere, opening a wide new window to the universe" (*Georama*, vol. 44, 2001: 3–49); and
- Reading, translating or decoding messages of nature, e.g., "The memories from past geological periods are codified inside dust particles and rare molecules" (*Kathimerini*, 15/6/1997: 20).

Science and technology as a dipole of promise and/or scare. This superordinate category contains metaphors that connote the positive and/or negative aspects of a large variety of technoscientific applications. Specifically, the metaphors of this kind represent S&T as the following:

- A dream, e.g., "Space travel is a dream becoming reality nowadays" (*Georama*, vol. 44, 2001: 3–49);
- A threat/risk/horror, e.g., "Fletcher like another Frankenstein was preoccupied to produce cloned species of salmon" (*Georama*, vol. 45, 2001: 86–91) or "Nuclear scientists were prepared for the forthcoming Armageddon" (*Vima*, 31/5/1998: 6);
- A battle/struggle/war, e.g., "The equations of Physics and Technology are transformed into killing weapons" (*Vima*, 6/10/1996: 32); or as
- Having ambivalent uses, e.g., "Cloning is a new method that resembles a knife; you can use it to cut the bread, or to kill" (*Vima*, 2/3/1997: 22).

The evolution of science and technology

With regard to the second dimension of metaphor analysis, which refers to the evolution of S&T, two distinct patterns were identified:

(1) scientific and technological evolution can be regarded as a sudden, or violent process;
(2) scientific knowledge can be seen as undergoing change in terms of a gradual process.

The scientific and technological evolution as a sudden and/or violent process. This superordinate category involves metaphors that represent the evolution of S&T as a sudden and historically discontinuous event. In particular, metaphors of this kind could represent the evolution of technoscientific knowledge as the following:

- Explosion, e.g., "The idea, which fell like a megaton bomb at the annual meeting of the American Association of Physics, was stated in 1959 by the American Nobel-winner Richard Feynmann" (*Georama*, vol. 46, 2001: 36–57);

- Revolution, e.g., "Cloning is expected to bring a cosmogonic revolution in Genetics" (Vima, 3/2/1997: 24);
- Birth, e.g., "The super-string theory was born in 1968 when Gabrielle Veneziano, an Italian researcher at CERN, observed that some properties of the elementary particles could be associated through the use of beta function" (*Focus*, vol. 26, 2002: 16–22); or as
- Rapid forward or upward motion, e.g., "The quantum computer constitutes a huge technological leap in the area of Informatics" (*Georama*, vol. 32, 1999: 13–18).

The scientific and technological evolution as a gradual process.
This superordinate category consists of metaphors that denote a gradual, continuous, and slow-pace evolution of S&T. In particular, when using metaphors of this type the S&T evolution could be represented as the following:

- Genealogical succession, e.g., "This program will be the cousin of Microsoft Windows" (*Vima*, 1/9/1997: 30);
- Fusion/combining process, e.g., "Contemporary cosmologists are nothing but the archaeologists of the Universe, driven during the last two decades to the marriage of two different specialties, those of Astrophysics and Nuclear Physics" (*Georama*, vol. 34, 1999: 2–51); or as
- An accumulative process, e.g., "So we patiently gather every pebble of knowledge, until the day that all the truth about the birth and evolution of our Solar System will shine before our eyes like a sun" (*Georama*, vol. 41, 2001: 2–61).

3.2 Frequencies of superordinate metaphorical categories

The nature of science and technology
From the total of 323 analyzed metaphors referring to the nature of S&T, the majority is almost equally shared between two fields: that of Space Science & Astronomy (106 metaphors) and that of Genetics & Biotechnology (99 metaphors). A considerable number (70 metaphors) refer to Natural Sciences, while metaphors referring to Engineering & Informatics are less frequent (48 metaphors). The distribution of metaphors according to the disciplinary fields they refer to and the distinct superordinate categories of the scheme of analysis they fall under are presented in Table 4.

The vast majority of metaphors produce an image of S&T as an activity that "extends the frontiers of knowledge" (195 of the 323 metaphors, namely 60.4% of the total). Space Science & Astronomy is the most typical case among the disciplinary fields examined,

Table 4. The frequencies and corresponding percentages of the representations of science and technology in newspaper and magazine articles according to disciplinary field

	Construct		Super–natural process		Extending the frontiers of knowledge		Promise scare			
Field	*N*	%	*N*	%	*N*	%	*N*	%	Total	
Space Science & Astronomy	8	7.5	2	1.9	89	84.0	7	6.6	106	100
Natural Sciences	13	18.6	6	8.6	40	57.1	11	15.7	70	100
Genetics & Biotechnology	7	7.1	11	13.1	60	60.6	21	19.1	99	
Engineering & Informatics	15	31.2	10	20.8	6	12.5	17	35.4	48	100
Total	43	13.3	29	9.0	195	60.4	56	17.3	323	100

evoking this kind of representation about S&T. Specifically, Space Science & Astronomy is almost exclusively represented as a discipline opening new perspectives and extending human experience to new, unforeseen landscapes, by being described as an activity of adventurous exploration, mystery resolution, or involving the receiving and decoding of messages from unknown worlds. Similar tendencies are apparent in the case of Genetics & Biotechnology and Natural Sciences. Conversely, the field of Engineering & Informatics by being more technological in nature seems to be underrepresented in the category of S&T as an activity "extending the frontiers of knowledge."

The second most popular representation of S&T is that of a "dipole of promise and/or scare," introduced by 56 metaphors (17.3%). Interestingly, this representation is quite frequently employed in articles primarily referring to Engineering & Informatics (21 metaphors) and secondarily to Genetics & Biotechnology (17 metaphors); since the corresponding representation is mainly related to the social applications of S&T, it seems that these two fields are portrayed in the popular scientific texts as the more socially influential.

Similarly, metaphors from the fields of Engineering & Informatics and Genetics & Biotechnology also constitute the majority in the superordinate category of S&T as a 'supernatural process' (10 and 11 instances respectively). The presentation of S&T as a supernatural process is less frequently employed in the fields of Natural Sciences and Space Science & Astronomy (only six and two instances respectively).

The sharing dominance of metaphors from the fields Engineering & Informatics and Genetics & Biotechnology in the categories of S&T as "a dipole of promise and/or scare" and of S&T as "a supernatural process" forms an overarching scheme that can be applied to both fields and can be described by the position that "S&T by handling supernatural powers (in other words 'playing God') can bring about fearful and/or desired outcomes." Similar representations have also been reported in articles published in the British press on Biotechnology (Liakopoulos, 2002), as well as in the Italian press about Informatics (Sensales, 1994). One might possibly attribute the fact that the general public seems to hold similar attitudes for both Engineering & Informatics and Genetics & Biotechnology to the prevalence of common representations within the corresponding disciplinary fields (Daamen et al., 1990; Agassi, 1996).

Finally, the representation of S&T as a construct is mainly found in articles relevant to the fields of Engineering & Informatics and Natural Sciences (15 and 13 of the total 43 instances respectively). This category is less frequently used in articles referring to Space Science & Astronomy (eight instances) and Genetics & Biotechnology (seven instances). Such metaphors compare scientific endeavor with man-made objects, (St Clair, 2002), which require inspiration, creativity and skillful performance. In other words, representations of this kind greatly emphasize the constructive and artistic dimensions of the technoscientific practice and may lead to a kind of commodity scientism, which in turn connotes a marriage of technoscientific knowledge with consumerism (Barns, 1993).

The evolution of science and technology

The outstanding field regarding the evolution of technoscientific knowledge is Engineering & Informatics, since almost half (47 of 102) of the metaphors referring to this topic concern this field. The rest of the metaphors are almost equally distributed between the fields of Space Science & Astronomy, Natural Sciences, and Genetics & Biotechnology. The frequencies of metaphors referring to the evolution of technoscientific knowledge, according to disciplinary field, are illustrated in Table 5.

With regard to the patterns of representation, there is a strong tendency, common in all

Table 5. The frequencies and corresponding percentages of the representations of the evolution of technoscientific knowledge in newspaper and magazine articles according to disciplinary field

	Sudden/violent process		Gradual process		Total	
Field	*N*	%	*N*	%	*N*	%
Space Science & Astronomy	13	68.4	6	31.6	19	100
Natural Sciences	12	75	4	25	16	100
Genetics & Biotechnology	12	66.7	6	33.3	18	100
Engineering & Informatics	27	57.1	20	42.8	47	100
Total	66	64.7	36	35.3	102	100

fields, to represent scientific evolution as "a sudden and/or violent process," since 64.7% of the metaphors attribute characteristics of rapid and dramatic changes in the course of technoscientific activity. This tendency is more pronounced in the field of Natural Sciences.

On the other hand, a considerable number of metaphors (36 of the total of 102 metaphors, or 35.3%) represent the evolution of scientific knowledge as "a gradual and accumulative process," as an expansion or extension of existing theories. This type of representation is more frequent in metaphors concerning Engineering & Informatics, since 20 of the 36 relevant metaphors refer to this field.

4. Conclusions

Active, creative metaphors are introduced in articles referring to all fields of scientific and technological knowledge. The majority of metaphors recorded are introduced in order to highlight the nature of S&T as an enterprise. Less frequently, metaphors also highlight the evolution of S&T.

Metaphors that refer to the nature of S&T are mainly found in articles about Space Science & Astronomy and Genetics & Biotechnology, and less frequently in articles on Natural Sciences and Engineering & Informatics. Furthermore, the nature of Space Science & Astronomy, Genetics & Biotechnology and Natural Sciences, which are more scientific than technological disciplinary fields, is presented through metaphors on average almost twice as frequently as the nature of Engineering & Informatics, which is a more technological discipline. In this way, the press tends to "black-box" the internal workings of Technology more than those of Science. This tendency may have some effect on the way the public perceives the relevant issues, since as some studies have shown, lay people tend not to realize the special features (e.g., designing, quality controls, etc.) differentiating technology from science and hence, tend to extrapolate the nature of science over that of technology; this, in turn, results in a common undifferentiated image for both areas (Daamen et al., 1990; Agassi, 1996).

The analysis of all the identified metaphors about the nature of S&T led to the conclusion that these metaphors can be classified into four superordinate categories which correspond to representations of these two areas: (1) a construct; (2) a supernatural process; (3) an activity extending the frontiers of knowledge; (4) a dipole of promise and/or scare.

Overall, science is overwhelmingly represented as extending the frontiers of knowledge. This kind of representation about science is a recurring one in a large variety of media, as

has been repeatedly verified by many international studies (Hornig, 1990; La Follette, 1990; Nelkin, 1990).

As far as evolution of technoscientific knowledge is concerned, it seems that S&T, in two out of the three relevant metaphors, is represented as a sudden or even a violent process. This representation applies to all the disciplinary fields. This could be due to the fact that the press and popular scientific magazines focus mainly on cutting-edge S&T, or on "science-and-technology-in-the making," promoting the innovative character of S&T. After all, novelty is one of the most prominent news values that journalists employ when selecting what is going to be covered in the mass media as "news" (Gans, 1979; Neidhardt, 1993). The tendency of popularized technoscientific texts to represent the evolution of S&T as a mainly discontinuous and sudden process resonates well with the way the public perceives the state of the relevant knowledge changes (Miller et al., 1997).

Almost half of the metaphors about techno-scientific evolution were isolated in articles referring to Engineering & Informatics. In this way, the popular scientific texts examined here (i.e., press articles and popular scientific magazine articles) cultivate a view according to which technology is more related to the notion of evolution and progress. Concerning the type of evolutionary change, the more "scientifically oriented" fields (i.e., Space Science & Astronomy, Natural Sciences, Genetics & Biotechnology) show a marked preference for the sudden/violent evolution representation. Conversely, the technological achievements corresponding to the field of Engineering & Informatics are almost equally treated as a revolutionary (i.e., forward leaps conforming to the "sudden/violent process" representation) and as a gradual accumulative process (such as a biological cycle).

In conclusion, despite some general trends (e.g., popularity of the "extending the frontiers of knowledge" representation in all scientific disciplines and presenting techno-scientific evolution as a sudden/violent process) within each disciplinary field different combinations of social representations seem to prevail. Figure 2 shows the most widely employed superordinate categories of metaphors, reflecting the dominant social representations evoked by the examined popular texts.

This differentiation means that the general public might not hold a universal image about S&T, as some surveys evaluating the public understanding of science and technology assume, but instead holds either differentiated images for each disciplinary field or clusters different fields according to their partial resemblances with regard to different aspects of their functioning (e.g., social applications, methodological procedures, etc.) (Daamen et al., 1990; Office of Science and Technology and the Welcome Trust, 2000).

However, despite this differentiation across the various disciplinary fields, all the superordinate categories of metaphors and the corresponding social representations they evoke play essentially the same fundamental role of maintaining the epistemic authority of S&T by overemphasizing the epistemological exceptionalism of the corresponding knowledge systems. This epistemological exceptionalism of S&T is accomplished by representing these areas as extending the volume of certified knowledge, constructing skillfully admirable things, handling supernatural powers, being capable of saving or destroying the entire humankind, and changing in an overwhelmingly rapid rate. Therefore, metaphors in the press and popular scientific magazines produce a paradox. On the one hand, they are employed in an attempt to juxtapose technoscientific endeavor with everyday life activities and entities, and consequently bring it conceptually closer to non-experts; on the other hand their use could contribute to enlarge the psychological gap between S&T and the ordinary man.

This functioning of popularized texts acts promotionally for the institution of S&T (Nelkin, 1994; Long and Steinke, 1996). This is particularly important, especially in an era where its credibility, prestige, and power, and the material resources allocated to it, are

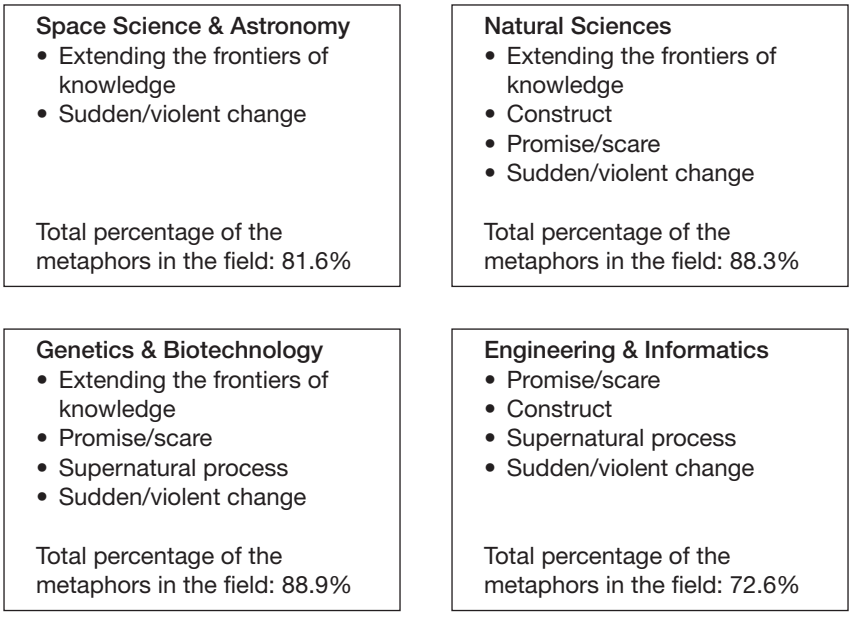

Figure 2. The prevailing catagories of metaphors in each disciplinary field.

deeply challenged by multiple social actors. Summarizing, we can say that the social representations evoked by the use of metaphors about S&T in the press and popular scientific magazines contribute to the upheaval of the cultural authority of the corresponding field, hence playing a significant role in the maintenance of the social autonomy and integrity of the techno-scientific profession (Gieryn, 1995).

The preceding analysis about the social representations of different disciplinary fields met in the popularized technoscientific texts can have, apart from the ones already identified here, many more far-reaching ideological and cognitive consequences (Goatly, 2000). Metaphor analysis is considered to provide an inroad into the production of knowledge as a cultural project, to which all kinds of scientific and non-scientific discourses contribute. "Knowledge transfer" through the transfer of metaphors among discourses can uncover the changes in the landscapes of knowledge (Maasen and Weingart, 2000). This paper attempted to trace only a snapshot of this process. A next step could be the exploration of the way such changes are perceived by the public.

Notes

1 These features are closely related to the "nomadic character" of metaphors, that is their circulation and interaction with various discourses over time, and their being powerful means to "catch" and direct attention to important issues, both in scientific discourse and in the media. See Maasen and Weingart, *Metaphors and the Dynamics of Knowledge*.

2 According to the latest Eurobarometer data (Eurobarometer 55.2, *Europeans, Science and Technology*), 37.0% of the European public mentioned the press, whereas another 20.1% mentioned the popular scientific journals when asked about their most prefered source for scientific issues. The corresponding figures in Greece are 43.9% for the press and 13.2% for popular scientific magazines.

3 *Eleftheros Typos*, *Eleftherotypia*, and *Kathimerini* were daily newspapers with Sunday editions, whereas *Vima* was a Sunday newspaper with no daily editions at the period of sampling. According to data supplied by the Association of the Greek Newspaper Owners, the mean number of issues sold over the period covered by this

study (1996to 1998) for each newspaper in our sample were: *Vima* (160,000 issues), *Eleftheros Typos* (120,000 issues), *Eleftherotypia* (90,000 issues), and *Kathimerini* (70,000 issues). These circulations account for 35% of the total readership of the daily newspapers and 65% of the total readership for Sunday newspapers in Greece over the period of the study. *Eleftheros Typos* and *Kathimerini* are considered conservative, while *Vima* and *Eleftherotypia* are considered liberal newspapers. *Focus* has been published monthly since March 2000 and has a circulation of about 45,000 copies per issue; its articles related to the four technoscientific disciplines of focus in this paper constitute 46% of all the articles published within it. Finally, *Georama-Experiment* has been published bimonthly since 1993 and has a circulation of about 40,000 copies per issue; its articles related to the four technoscientific disciplines of focus in this paper constitute 22% of all its published articles. Other thematic areas of concern apart from S&T in both magazines are Environment, Geography, Ethnology, History, Archeology, Psychology, Economics and Mathematics.

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