

Science Communication on Nanotechnology in the Brazilian Media *

Comunicación científica sobre nanotecnología en los medios brasileños

Comunicação científica sobre nanotecnologia na mídia brasileira

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This paper examines the communication on nanotechnology in Brazilian media associated to the interests and values of different social groups, and explores which kind of communication models they use and which kind of contents they privilege. Three different media were analysed: the science features of the broadcast TV show Bom Dia Brasil (“Good Morning Brazil”); the science column of the Folha de S. Paulo newspaper; and a non-random sample of Nanotecnologia do Avesso (“Nanotechnology Inside Out”), a chat show on web TV. The timeframe was established between 2008 and 2010, a period that follows the four best-financed years of Brazilian nanotechnology policy, after the launching of a national program in 2004. The methodological approach was quantitative and qualitative content analysis. The study concluded that communication of nanotechnology in Brazilian media is characterized by tensions and polarisations. On the one hand, the conventional media support the stabilisation of nanotechnology and emphasise its potential for innovation with discourses based on linear models. On the other hand, the alternative media expose the instability of nanotechnology, accentuate its risks with dystopic discourses and highlight the need for the application of the precautionary principle and the establishment of regulations.

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Keywords: science communication; media; nanotechnology; public policies

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Este artículo examina la comunicación sobre nanotecnología en los medios de comunicación brasileños que responden a los intereses y valores de diferentes grupos sociales, e indaga cuáles son los modelos de comunicación utilizados y los contenidos privilegiados. Se analizaron tres medios diferentes: las secciones de ciencia del programa de televisión *Buen Día Brasil*; la columna de ciencia del periódico *Folha de S. Paulo*; y una muestra no aleatoria de *Nanotecnologia al Revés*, un programa de entrevistas en web TV. El marco temporal se estableció entre 2008 y 2010, un período que sigue a los cuatro años mejor financiados de la política brasileña de nanotecnología, luego del lanzamiento de un programa nacional para el área en 2004. El enfoque metodológico fue el análisis de contenido cuantitativo y cualitativo. El estudio concluyó que la comunicación sobre nanotecnología en los medios brasileños se caracteriza por sus tensiones y su polarización. Por un lado, los medios convencionales respaldan la estabilización de la nanotecnología y enfatizan su potencial de innovación con discursos basados en modelos lineales. Por otro lado, los medios alternativos exponen la inestabilidad de la nanotecnología, acentuando sus riesgos con discursos distópicos y resaltando la necesidad de la aplicación del principio de precaución y el establecimiento de regulaciones.

Palabras clave: comunicación de la ciencia; medios de comunicación; nanotecnología; políticas públicas

Este artigo examina a comunicação sobre nanotecnologia em mídias brasileiras que respondem a interesses e valores de grupos sociais diferentes, e indaga sobre quais são os modelos de comunicação utilizados e os conteúdos abordados. Foram analisadas três diferentes mídias: as seções de ciência do programa de TV aberta *Bom Dia Brasil* e do jornal *Folha de S. Paulo*, e uma amostra não aleatória dos programas *Nanotecnologia do Avesso*, programa de entrevistas em web TV. O período de análise foi estabelecido entre 2008 e 2010, período que segue os quatro anos mais bem financiados da política brasileira de nanotecnologia, após o lançamento de um programa nacional para a área em 2004. A abordagem metodológica foi a análise de conteúdo quantitativa e qualitativa. O estudo concluiu que a comunicação da nanotecnologia na mídia brasileira é caracterizada por tensões e polarizações. Por um lado, a mídia convencional apoia a estabilização da nanotecnologia e enfatiza seu potencial de inovação com discursos baseados em modelos lineares. Por outro lado, a mídia alternativa expõe a instabilidade da nanotecnologia, acentuando seus riscos com discursos distópicos e destacando a necessidade de aplicação do princípio da precaução e o estabelecimento de regulação.

Palavras-chave: comunicação da ciência; mídia; nanotecnologia; políticas públicas

Introduction

Nanotechnology is a strategic field in the science, technology and innovation policies in many countries, including those in Latin America (Invernizzi and Foladori, 2012). Brazil's nanotechnology policy started to be coined in 2000, and a national program was designed in 2003 and included in the 2004-2007 Multi-Year Plan of the Ministry of Science and Technology. This initial plan was reinforced in 2005 with the launch of the National Nanotechnology Program (NNP) that added substantial funding to the initiative. In 2012, the NNP was revitalised with the promulgation of the Brazilian Nanotechnology Initiative (BNI), which remains in force.

This emerging technology was characterised as a window of opportunity for the country's search for competitiveness (MCT, 2003). Increasing competitiveness through innovation has been the central goal of Brazil's nanotechnology policy. Since the inception of the first nanotechnology program, the importance of public communication on this new technology was highlighted, despite the fact that only a few actions were implemented in the following years (Invernizzi, Körbes and Fuck, 2012).

The subject of nanotechnology has attracted increasing mass media attention around the world. Analyses of nanotechnology communication in the media have found that there has been a growing variety of content on the matter over time (Stephens, 2005; Faber, 2006) and that this content has been mostly optimistic (Stephens, 2005; Lösch, 2006; Gaskell *et al.*, 2005; Masami, Hunt and Masayuki, 2008; Invernizzi and Cavichiolo, 2009; Tyshenko, 2014). This optimism has been fuelled by futuristic narratives and images, especially of nanorobots (Loesch, 2006), more common at the beginning of the years 2000s, and by news media content narrowly focused on scientific innovation and near-term research applications (Tyshenko, 2014). Gaskell *et al.* (2005) found that emphasis on the potential benefits of nanotechnology differs from country to country. In Brazil, Amorim (2008), Invernizzi (2008) and Invernizzi and Cavichiolo (2009) showed that the promises of nanotechnology were strongly emphasized by different media.

There have been a number of recommendations and diverse initiatives in several regions, especially in Europe, regarding science communication and strengthening public engagement with the development of nanotechnology since its initial phases (RS and RAE, 2004; Priest, 2008; Kurath and Gisler, 2009; Macnaghten and Guivant, 2011). However, public engagement approaches in nanotechnology are still heavily influenced by the deficit model (Kurath and Gisler, 2009; Priest, 2008), revealing the need for greater changes in the epistemological and methodological approaches (Kurath and Gisler, 2009).

The views on nanotechnology spread by the media have considerable influence on the public perception of the subject (Gaskell *et al.*, 2005; Faber, 2006). Issues regarding the communication of risks and social implications of a new technology are of particular importance when its public acceptance is at stake. Krabbenborg and Mulder (2015) observed that the more limited framework of risk-benefit discourses overlapped the broader social and ethical issues. The study by Retzbach and Maier

(2015) found that communication on science uncertainties did not affect the lay public confidence in science nor their previous visions on science, but had some positive effects in their interest for science and technology.

In this article, we analyse the public communication on nanotechnology in Brazil. We chose to focus the inquiry during the period 2008-2010, following the “boom” of public investments to promote nanotechnology in the country, which occurred between 2005 and 2008 (MCTI, 2016).¹ This temporal selection is considered fruitful to capture the characteristics of public communication and possible different approaches once nanotechnology started to be something concretely developed in the country. The central aim is to examine communication regarding nanotechnology in media that cater to different social groups and ask, through a comparative analysis, which are the characteristics of the dissemination models that are used and which content is privileged by different media. To that end, we study the content divulged in three different types of Brazilian media, described in the following section.

The plan of the article is as follows. In the first section, we characterize the media under study. The second section is dedicated to explain the research methodology. In the third session we present the comparative analysis of content on nanotechnology found in the three media. The article is brought to a close with some conclusions.

1. Methods

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The first criterion used to select the forms of media for this research was based on a study on public perception of science conducted by the Ministry of Science and Technology in collaboration with the United Nations Educational Scientific and Cultural Organisation (UNESCO) (MCT, 2011) involving people over the age of sixteen. This study showed that the most frequently used media concerning science and technology information in Brazil are television, newspapers, magazines and the Internet. In comparison with a previous study, the main change found was an increased use of the internet. An additional criterion was to represent media features addressed to different kinds of publics. With this in mind, we analysed nanotechnology communication in three different media: television, newspaper and internet.

The TV programs consisted of all five reports on nanotechnology broadcast on the television daily news show *Bom Dia Brasil (Good Morning Brazil)* between 2008 and 2010. Four of them were part of a series called ‘Nano Universe’ and one was presented in a program section entitled ‘You didn’t know it, but this already exists’.² The audience of this television news program is mainly composed of middle-class adults.

1. Although the first policies aimed to promote nanotechnology in Brazil are traced back to 2001, between 2005 and 2008 there was a significant raise in public investments by the Ministry of Science and Technology and its agencies. Then the investments started to decline up to 2013, when an ephemeral rise of funding, that lasted less than two years, was registered (MCTI, 2016).

2. The reports were retrieved from: <http://g1.globo.com/bom-dia-brasil/>. Available at: <http://comercial2.redeglobo.com.br/programacao/Pages/BomDiaBrasil.aspx#>. Date of reference: February 10, 2013.

From the printed edition of newspaper *Folha de S. Paulo*, the best-selling newspaper in Brazil from 2002 to 2009, we examined nineteen articles that were published in the newspaper features “*Folha Science*” and “*More Science*” over the same time period.³ According to the newspaper itself (*Folha de S. Paulo*, 2011), 41% of its readers are upper class, in comparison with only 3% representation of these group in the total population. Three quarters of them have a university degree and 24% also have a post-graduate degree. For the country in general, these rates are 13% and 2%, respectively. The column “*More Science*”, discontinued in May 2010, was aimed at a more informed and demanding readership. It was characterized by analytical and often critical articles on science and technology. It was very different from standard science columns, and was written by a scientific journalist, Marcelo Leite, with a PhD in Social Sciences.⁴

Finally, we selected seventeen chapters of the internet TV program *Nanotecnologia do Avesso (Nanotechnology Inside Out)*, which corresponded to a non-random sample of 20% of the eighty-six programs shown during its first two years (2009 and 2010).⁵ A non-random sample was defined based on the following criteria: variety of themes, different areas of knowledge and diversity of national and foreign institutional sources. We tried to represent, in the most balanced way possible, the proportionality in relation to the total 86 programs presented during the period and available on the blog, while giving a relevant weight to the representation of the diversity of actors interviewed. According to Martins and Fernandes (2011), an analysis of the audience in the first one hundred episodes of the program, based on data on the server, showed that each episode was followed by an average of 1,089 internet users, with ratings tending to be higher when representatives of trade union movements were interviewed.

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An important criterion was to incorporate media that were more or less explicitly tied to different relevant social groups’ interests, disseminating different ideas and practices. In this respect, it is important to note that Globo Organisations and the Folha Group are two of the four largest media groups in the country, along with Abril Publishing and the Estado Group.

Another criterion was to incorporate a form of dissemination of nanotechnology in a “new media”. The Internet is increasingly used to access newspapers, television and radio and any other form of digitized information or cultural product, such as movies, databases, music, books and others. The tendency is for younger users to access different media through computers, which is transforming the information dissemination platform, the processes of receiving information and the relationship between transmitters and receivers, which now incorporates more possibilities for interactivity (Castells, 2012).

3. Until 2012, the content of the printed edition of *Folha de S. Paulo* was different from the online content: *Folha.com*. Afterwards, the digital and printed content are the same, but with a free online reading limit per month. For more information, access: <https://economia.uol.com.br/noticias/redacao/2012/06/21/folha-passa-a-cobrar-por-conteudo-digital-assinante-uol-tem-acesso-gratis.htm>. Date of reference: October 28, 2019.

4. In May 2010 the journalist started writing in an online section of the journal. See: <http://www1.folha.uol.com.br/colunas/marceloleite/index.shtml>. Date of reference: December 11, 2014.

5. The interviews were accessed at: http://www.nanotecnologiadoavesso.org/tv_past. Date of reference: July 08, 2012.

The development of new information and communication technologies has enabled a renewal of the media that affects society's interaction with the mass media, creating new forms of sociability, as highlighted by Ribeiro (2009). In this context emerges the web TV, which allows the participation of the user as a content producer and no longer as a mere receiver of messages. It also makes possible the segmented programming for audiences with specific interests. By the way, *Nanotechnology Inside Out* often included the interaction of Internet users with the interviewees. The web TV is expected to grow in the coming years driven by the expansion of Internet access, which underpins its infrastructure (Ribeiro, 2009) and is booming in Brazil, accompanied by improved connection quality represented by the growth in broadband access.⁶

This justifies the analysis of *Nanotechnology Inside Out*, which was part of the 'Public Engagement in Nanotechnology' project of the Nanotechnology, Society and Environment Network (Renanosoma). The project was financed by the Brazilian Council for Research (CNPq) until April 2009 (Martins and Fernandes, 2009), which enabled the program to be broadcast on the commercial web TV AllTV (<http://www.alltv.com.br/>). According to the coordinator of Renanosoma and *Nanotechnology Inside Out* (Martins, 2013), after a time without financing, the program was linked to a research project at the University of São Paulo. The program was then broadcast on IPTV, a web TV channel and the cable TV channel of the University of São Paulo (www.iptv.usp.br/), with a smaller audience that it had attracted on commercial web TV.

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The network Renanosoma has an activist profile. It is openly critical to the way nanotechnology policy has been designed and implemented in Brazil and demands more public participation in decision-making. More recently, a campaign to discuss nanotechnology promoted by members of Renanosoma, along with researchers and activists from other organisations, resulted in the founding of the Observatory for Nanotechnology in the Americas, during the People's Summit in June of 2012.⁷ In January 2014, another scientific program called Nano Alert, aimed at workers, trade union leaders and trade union representatives, was initiated.

All the articles and programs analysed are listed at the end of the article with complete references.

The quantitative and qualitative analysis of the material collected from the selected media was carried out through content analysis (Bardin, 1977), with an a priori explanation of the theoretical background (Moraes, 1999). Content analysis was

6. This directly interferes with the ability to transfer information, and the wider the bandwidth, the more content can be accessed. According to IBOPE Nielsen Online's Net Speed Report study, the number of active users of connections of more than 2 MB in June 2012 was 91% higher than in June 2011. Already the number of users using connection up to 512 KB fell 39% in the same period. According to IBOPE Nielsen Online, the total number of people with access at home or at work in June 2012 was 68 million and of those with 50.5 million were active users. This number increased to 82.4 million users considering Internet access in any environment (Ibope, 2012).

7. For more information see: <http://observatorionanoamericas.blogspot.com.br/>. Date of reference: January 31, 2014.

conducted using category analysis, in which the meanings of the texts were classified into categories related to the research question. This technique was used in three stages, following Bardin (1977): 1) pre-analysis (selection and organisation of the material, with a first reading and decision on which materials are in line with the aims of the study, plus a preparation of provisional hypotheses); 2) exploration or coding of the material (another reading, identification of meanings and grouping into empirical categories related to the research questions); and 3) treatment and interpretation of results (identification of different or similar characteristics in the data, categorizing them into thematic units, followed by interpretation).

During the coding stage, we benefited from some categories previously developed by Invernizzi (2008) and Invernizzi and Cavichiolo (2009). The variables and indicators were constructed from the interface between the theoretical review and a first analysis of the materials in question, and later adapted to the characteristics of each scientific communication medium. This resulted in an analysis script displayed in Annex. Only some of the dimensions of analysis are used in this article.

2. Comparative analysis of nanotechnology in three Brazilian media

A key aspect for the comparative analysis of the media is the identification of the social actors that are represented. On *Good Morning Brazil* and in *Folha de S. Paulo* the predominant voices are those of researchers in the natural sciences, health and engineering. On the other hand, on *Nanotechnology Inside Out*, the interviewees (both researchers and non-researchers) work mostly in the field of the human sciences, with natural sciences coming in second place, followed by applied social sciences and multidisciplinary fields in third place. One particularly interesting feature of this program is the participation of people with links to organized social movements and the occasional participation of teachers of elementary education. Neither of these groups is found in the other media under study. Therefore, it is clear that each medium empowers certain groups of the social and technical network that constitutes nanotechnology.

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Nanotechnology Inside Out and *Good Morning Brazil* concentrate heavily on domestic scientific and technological production, but without ignoring overseas developments, while *Folha de S. Paulo* tends to focus more on developments in other countries. Thus, *Folha* provides more information about science and technology from developed countries than our own country or countries with similar needs to ours, such as the rest of Latin America. This can be seen as a manifestation of the region's scientific and technological dependent development, which resulted from economic accumulation models based on technology imports (Thomas, 2011).

In the following subsections, the approaches of the three media regarding the definition, visions and potential benefits, risks and ethical, legal and social implications of nanotechnology are examined. These topics are followed by a reflection on the meaning of communication concerning nanotechnology promoted by the media in question.

2.1. Concepts and definitions of nanotechnology

Concepts and definitions of nanotechnology, far from been merely technical, are related to the interests of different parties and the dynamics and the circumstances that lead to its promulgation and stabilisation. According to Lacour and Vinck (2011), the choice of terms used to designate an object is carefully pondered by interested parties, especially when the prospect of regulation is involved. Therefore, the definitions are a social construction and can be guided by different objectives, such as encouraging innovation and technological development or the evaluation and management of potential risks.⁸

Definitions of nanotechnology vary greatly among the media under study, as can be seen in **Table 1**. The nano-scale, invisible to the human eye, is the first epistemological obstacle to understanding nanotechnology (Crone, 2006; Sánchez-Mora and Parga, 2011) and this is certainly one of the reasons why the definition of the nanoscale is found in all the media in question, usually referred to as a billionth of a meter or 10^{-9} m.

Table 1. Concepts and definitions of nanotechnology portrayed by TV programs and journal articles

Concepts and definitions of nanotechnology	<i>Good Morning Brazil</i>	<i>Folha de S. Paulo</i>	<i>Nanotechnology Inside Out</i>
Nanometric scale	1	18	9
Comparisons with well-known and familiar structures	1	3	3
The nanotechnology measurements and the nanometric scale aren't new	2	0	0
New properties and/or new functions that differ from the properties of materials on other scales	5	16	5
Nanotechnology is a new frontier of science and offers new solutions and creates new problems for society	0	3	9

Source: Elaborated by the authors based on analysed materials (2017).

To explain the nanometric scale, there are recurring comparisons with well-known and familiar structures such as grains of sand (Gomes, 2009) and the thickness of a hair (Mioto, 2010a; Leite, 2009; *Folha de S. Paulo*, 2008c; Schulz, 2009; Santos, 2009). Although this may facilitate a representation of the scale, it represents nanostructures very inaccurately.

The argument highlighted on *Good Morning Brazil* is that neither the nanotechnology measurements nor the nanometric scale are new, because they have been present in medicine (Losekann and Gilz, 2009), even in the stained glass in old church windows (Duarte and Araújo, 2009a) for quite some time and nanotechnology dimensions are

8. According to Lacour and Vinck (2011), businessmen are interested in simple and operational regulations that encourage industrial innovation, lending support to the idea of a dimensional definition limited to the scope of 1 to 100nm, without taking into account other criteria such as surface area.

found in plants, dust, proteins, viruses and DNA molecules (Duarte and Araújo, 2009a). These definitions help to strengthen the idea that nanotechnology is nothing new, and this might perplex the audience because the reports open up visions of a new universe to be explored by this science.

This apparent contradiction (because nanotechnology has been used empirically in the past and there are numerous processes on the nanoscale in nature) could be a result of a desire to press the point that nanotechnology is harmless. This would remove any anxiety that viewers might feel because they are faced with something new and could avoid a debate concerning the risks that come in the wake of emerging technologies. As argued by Dupuy (2008), it seems that scientific double-talk is being used. On the one hand, they speak of the great possibilities for scientists to create new things in order to garner support for research projects; but on the other hand, they admit the modest nature of research and associate nanotechnology with natural phenomena to avoid questions from groups who are concerned with its evaluation and regulation.

In *Folha de S. Paulo*, a piece by Leite (2009) in the column “More Science”, clearly addresses the social construction of the dimensional framework for nanotechnology. The author, by emphasizing the term nanoparticles and associating them with nanoparticularity, made it clear that their properties change rapidly on the nanometric scale and used this definition to argue for a need to regulate nanotechnology. The writer also explained that the concerns of agents involved in establishing criteria to define nanoparticles that are harmful to human health and the environment are in contrast with the aims of entrepreneurs in the industrial sector, illustrating how political definitions of nanotechnology can become and any arguments related to them.

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The nanometric scale is associated with new properties and/or new functions that differ from the properties of materials on other scales in *Good Morning Brazil* (Gomes, 2009; Duarte and Araújo, 2009a; Duarte and Araújo, 2009b; Losekann and Gilz, 2009; Kovalick and Suzuki, 2009), in *Folha de S. Paulo* (Zolnerkevic and Fert, 2008; Zolnerkevic, 2008; Garcia, 2008a; 2008b; Geraque, 2008; Bombig, 2009; Bonalume Neto, 2009; *Folha de S. Paulo*, 2008a; 2008b; 2009, Mito, 2010b; Miranda, 2010; Leite, 2008b; 2010a; Righetti, 2010) and on *Nanotechnology Inside Out* (Cossliello, 2009; Gama, 2009; Jardim, 2009; Rattner, 2009; Salomão, 2009; Santos, 2009; Schulz, 2009; Miller, 2010; Jensen and Vieira Filho, 2010; Minozzi, 2010; Nordmann, 2010).

On *Nanotechnology Inside Out*, several interviewees have recognized that nanotechnology creates a new frontier of science that can be applied to several branches of industry and, as a result, new solutions and new problems for society will arise (Gama, 2009; Jardim, 2009; Jensen and Vieira Filho, 2010; Rattner, 2009; Salomão, 2009; Minozzi, 2010; Nordmann, 2010; Bensaude-Vincent, 2010), leading to demand for the regulation of nanotechnology (Rattner, 2009; Nordmann, 2010; Blau, 2009).

To conclude this session, it is worth noting that on *Good Morning Brazil* and in *Folha de S. Paulo* (with the exception of the column “More Science”), the concept of

nanotechnology appears to be strongly linked to the idea of material artefacts, whereas on *Nanotechnology Inside Out*, there are more references to its social configuration.

2.2. Visions for nanotechnology

Visions for the future of nanotechnology, understood not only as technological projects but also as descriptions of a future technological society, are directed to delimit and consolidate fields of research and seek support and legitimacy for financing of research and even to influence the course of technological development (Fiedeler, Grunwald and Coenen, 2005; Invernizzi, 2008). According to Invernizzi and Cavichiolo (2009: 148), “these visions arise and spread among scientists and policy makers and are then taken up and divulged in the media”.

We analysed the visions portrayed by the media under study based on the four categories of visions for nanotechnology proposed by Fiedeler, Grunwald and Coenen (2005), which can have different degrees of concreteness. **Table 2** shows the frequency of such visions and provides some examples.

Table 2. Visions for nanotechnology

<i>Visions for nanotechnology</i>	<i>Good Morning Brazil</i>	<i>Folha de S. Paulo</i>	<i>Nanotechnology Inside Out</i>
Problem-related visions	Found in 2/5 of TV reports.	Found in 3/19 articles	Absent
Assembler-based visions	Found in 1/5 TV reports.	Found in 1/19 articles.	Found in 5/17 webTV reports.
Visions of product improvement	Found in 3/5 TV reports	Found in 2/19 articles	Found in 3/17 webTV reports
Material-based visions	Found in 1/5 TV reports	Found in 12/19 articles	Found in 7/17 webTV reports

Source: Elaborated by the authors based on the categories proposed by Fiedeler, Grunwald & Coenen (2005).

The first type of visions, the problem related visions, portray a problem solution using nanotechnology and usually involve a high degree of speculation. They are more frequent in *Good Morning Brazil* reports, occasional in *Folha de S. Paulo*'s articles and absent in *Nanotechnology Inside Out* web TV reports. As examples, we can cite the investigation of changes in the cellular development and ageing process (*Folha de S. Paulo*, 2008c), the diagnosis of cancer with nanosensors (Losekann and Gilz, 2009; Kovalick and Suzuki, 2009) and its treatment with drugs that act directly on the affected cells with no side effects (Losekann and Gilz, 2009), a more accurate diagnosis of tumours with the aid of nanoscopic molecules and image technology (Garcia, 2008a) and the return of anti-HIV drugs, which were ruled out in the 1990s because of the toxic nature of ammonium salts, once this component could be replaced by gold nanoparticles (*Folha de S. Paulo*, 2008b).

The assembler-based visions, more common in the media in the early 2000s, are scarcely present in Brazilian media by the end of the same decade. Only one report of *Good Morning Brazil* and one article of *Folha de S. Paulo* address the subject.

The first depict nanorobots or molecular size machines that can cure or kill sick cells (Losekann and Gilz, 2009) and the second nanomachines capable of kill affected cells in the early stages of a disease (Mito, 2010a). These kinds of visions are contested or depicted in a less optimistic way in six web TV interviews in *Nanotechnology Inside Out*. According to Dulley (2010), molecular manufacturing is a new nature, 'a synthetic nature' (Costa and Dulley, 2010). According to interviewee Bensaude-Vincent (2010), at the moment nanotechnology is already applied in some innovations, but there are already signs that the next step will be the development of nanorobots, autonomous nanosystems and then a breakthrough in the ecosystem, but it is not known yet if these developments will be actually viable. Schulz (2009), referring to research on the interface of living organisms and inanimate matter, also doubts the viability of nanomachines as depicted in futuristic visions.

Visions of product improvement were more present in *Good Morning Brazil* than in the other media. For example, antibacterial materials are incorporated to food containers, hair driers, etc. (Duarte and Araújo, 2009b), and nanosensors to control water quality (Gomes, 2009). These visions are associated with significantly improved consumer product performance as a result of incorporating nanotechnology into different fields of industry, such as electronic (Zolnerkevic and Fert, 2008; Bonalume Neto, 2009; Cossello, 2009) and food (Duarte and Araújo, 2009b). For example, a new technique enables the recording of 300 current DVDs on one disc (Bonalume Neto, 2009). According to interviewee Nordmann (2010), in *Nanotechnology Inside Out*, this new way of innovating requires a totally different form of regulation.

The most common visions disseminated by the media are material-based visions (one of the most concrete categories), dedicated to the development of new materials, with expectations of new functions that can be developed by exploring the properties of materials. In the *Good Morning Brazil* reports and in the *Folha de S. Paulo*'s articles, the new materials are associated to increased efficiency and better quality of life in examples such as application to carbon nanotubes with elasticity, which can be used to make bulletproof vests (Zolnerkevic, 2008) and more resistant concrete (Jensen and Vieira Filho, 2010) or used in new research techniques (Mito, 2010a). These visions often leave unanswered questions such as what can be done with new materials like 'nanossanfona', a highly stretchable molecular structure made of silver, similar to an accordion (*Folha de S. Paulo*, 2009). *Nanotechnology Inside Out* addressed both efficiency and social adverse effects and risks of new materials, such as the use of silver nanoparticles in food (Miller, 2010) and appliances (Schulz, 2009). In the analysis conducted in the interview with Minozzi (2010), nanotechnology is a tool for improving different industries and reducing the amount of material used. For example, instead of 100g, 10g of heavy metals could be used in the catalytic converter of a car.

Good Morning Brazil and *Folha de S. Paulo* highlight nanotechnology innovations and explain the great interest of entrepreneurs in the development and commercialisation of new products with high value added. In this way, they form an optimistic vision, a vision that nanotechnology will usher in a series of generally positive effects on the quality of life, with the development of more efficient materials and products that will open up new markets, improve industrial competitiveness and economic development. Nanotechnology will also lead to the development of new instruments and research

into the properties of new materials for scientific and technological development and the preservation of the environment.

On the other hand, on *Nanotechnology Inside Out*, any positive expectations related to the development of nanotechnology and its potential for innovation are broached along with concerns over uncertainty and the potential risks to human health, the environment and legal, social and ethical implications. These visions can be viewed as critical, and sometimes even dystopian, as they discuss adverse living conditions such as oppression, social exclusion and environmental pollution and often question political attitudes to nanotechnology.

Visions for nanotechnology can also be identified on the temporal horizon (Paschen *et al.*, 2004 quoted by Fiedeler, Grunwald and Coenen, 2005). In *Folha de S. Paulo*, most of the articles that discuss how things will change over time project an unspecific future. On *Good Morning Brazil* the reports are replete with the vision that the applications of nanotechnology are already available for use. Both media explain the vitality of research and point out that at the current stage of development there are some nanotechnology prototypes that can be used by industrial processes, in research or that are already for sale.

Likewise, all the interviews on *Nanotechnology Inside Out* mention that there are already nanotechnology products on the market, especially in developed countries, but also in Brazil. The new materials and products satisfy the desires of consumers according to some interviews; according to others, product innovation is driven by commercial interests. It has been stated in a number of interviews that consumers are not always informed that the products they buy contain nanomaterials because there is no labelling and regulation for the industrialisation and commercialisation of nanotechnology products except in very rare cases.

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2.3. Potential benefits, risks and ethical, legal and social implications of nanotechnology

The possible risks and ethical, legal and social implications of nanotechnology to society, health and the environment are not mentioned in the reports of *Good Morning Brazil*, mentioned a little in *Folha de S. Paulo* and mentioned a great deal on *Nanotechnology Inside Out*. On *Good Morning Brazil*, the limitations found in the development of nanotechnology are presented as temporary by the scientists and engineers who are interviewed. This is a characteristic aspect of the deficit model of science communication. Unidirectional models are connected to several dimensions of linear determinisms, while models of dialogue are designed to overcome them. The case under analysis can be categorised according to Lewenstein (2003) definition of the deficit model, according to which, scientific communication should bridge the information gaps for a passive, monolithic and homogeneous audience. This landscape is synthesized in **Table 3**.

Table 3. Emphasis placed by the articles on benefits, risks and ethical, legal and social implications of nanotechnology

	<i>Good Morning Brazil</i>	<i>Folha de S. Paulo</i>	<i>Nanotechnology Inside Out</i>
Only benefits	4/5 TV reports	3/19 articles	None
Emphasis on benefits	1/5 TV reports	13/19 articles	None
Emphasis on risks and/or ethical, legal and social implications	None	3/19 articles	17/17 WebTV reports

Source: Elaborated by the authors based on analysed materials (2017).

In *Good Morning Brazil*, four of the five reports focus only on benefits and one report emphasise benefits. There aren't reports that highlight risks or ethical, legal and social implications. In *Folha de S. Paulo* three of the nineteen articles stress only benefits, thirteen highlight benefits and merely three emphasise on risks or ethical, legal and social implications. Furthermore, all of the seventeen programs of *Nanotechnology Inside Out* emphasise risks and social, legal and ethical implications.

In *Folha de S. Paulo*, the ethical, legal and social risks and implications of nanotechnology were central issues in only three articles, all written by Leite (2008a, 2008b and 2009), a science journalist with academic qualifications in Social Sciences, as pointed out earlier. These articles focused first of all on risks to human health, such as cancer through inhaling carbon nanotubes, especially long multi-walled nanotubes (MWNT) that could behave in a way similar to long asbestos fibres (Leite, 2008a and 2008b). There is also mention to the risks to the environment. By considering benefits and risks, these texts came close to the dialogue model and fulfilling the role of educating readers and preparing them to take part in the debate. In this case, the approach is close to what Lewenstein (2003) presents as the lay expertise model, which promotes interaction between scientists and communicators and the local people, considering the development of real communities and assuming a commitment to empower the local community.

Regarding the ethical implications of nanotechnology, Leite's articles in this newspaper discuss the need to popularise science and democratise science decision-making. Among the legal matters raised is the need to regulate nanoparticles for their use in new processes such as the diagnose and treatment of diseases, putting in practice the precautionary principle. The author also stressed the urgent need for public information concerning nanotechnology and the participation of citizens when it comes to defining the priorities for research in the field, especially research financed by public funds.

Unlike *Good Morning Brazil* and *Folha de S. Paulo*, where there is little content on or reference to risk, *Nanotechnology Inside Out* programs always included questions to the interviewees on such matter. So, both risks and benefits are present in the discussion. Thus, to a certain extent the discussion is polarized, revealing a very

diverse array of interests that are at stake in the development of nanotechnology. Of the seventeen shows that were analysed, 16 dealt with risks, and on three occasions it was the central theme (Blau, 2009; Santos, 2009; Nordmann, 2010).⁹ During the interviews, the risks to the health of workers who manufacture or use nanotechnology products were highlighted, along with risks to nanotechnology researchers and consumers. Risks to the environment were also frequently mentioned. In this media, a topic appeared that was not addressed by the others, which is the economic risks of investing in an emerging technology and its effects on employment and concentration of capital.

The central aspect of the risk analysis of nanotechnology featured in the internet program is how material property changes on the nanoscale. According to Salomão (2009), on this scale, nanoparticles change their properties very easily and tend to agglomerate and form slightly different secondary particles that can prove to be more problematic. Santos (2009) also points out in his interview that smaller particles are more aggressive and reactive.

The notoriety of the analysis of changing properties on the nanoscale on *Nanotechnology Inside Out* evidences the interests of the social groups engaged in regulating nanotechnology. Moreover, there is a clear commitment from the part of the group in charge of the program (Renanosoma) to enlarge the perception of risks associated to nanotechnology and the demands for mandatory regulation. In this sense, the program seeks to enlist viewers as potential allies, together with workers groups, consumers and environmentalists. The interviewer, as well as many interviewees, sustains their arguments by claiming that the precautionary principle is not being applied, nor is the transparency principle, nor that of public participation, and the health and safety of workers and consumers are not being protected. In sum, the program continuously emphasizes that measures that could reduce exposure to potential harmful effects are not being taken, and the steps towards an effective regulation have been too slow.

The main implications highlighted in the program were environmental and health issues, economic and social problems, general public and workers information, educational questions and public participation. The legal implications discussed included the regulation of nanotechnology, the labelling of products containing nanotechnologies and intellectual property issues. The most debated ethical matters were the inequality of social appropriation of the benefits of nanotechnology, abuses of the new technology, decisions regarding whether or not to use products that contain nanoparticles, and relationships between companies and universities.

9. Only the interview with Moraes (2009) included no discussion regarding the risks of nanotechnology, but addressed the social implications of nanotechnology.

Discussion

The comparative analysis of the three media shows that the definitions of nanotechnology vary a great deal from one medium to another, depending on who produces them and under what circumstances they are stated. On *Good Morning Brazil* and in *Folha de S. Paulo* the concept of nanotechnology emphasizes the material aspect and provides minimal explanations of its social configuration through a social and technical network. However, this aspect is often debated in *Nanotechnology Inside Out*.

All the media describe the new properties and functions of matter on the nanoscale, but do this in different ways, highlighting the perspectives of different actors that intend to influence the agenda of the public policies for science and technology, by hailing the potential for innovation that these properties offer or remarking the risks that are involved. On *Good Morning Brazil* and in *Folha de S. Paulo* they emphasize the potential benefits of more efficient products and how they can open up new markets and make advances in healthcare, improve the quality of life and preserve the environment. These visions are reproductions of discourses based on linear models, such as science neutrality and relentlessness and continuous progress of science and technology. On *Nanotechnology Inside Out*, on the other hand, there are discussions of the potential risks and social, legal and ethical implications of nanotechnology, which at times reach dystopian levels. These shows also concentrate on demands for the application of the precautionary principle and mandatory regulation.

The communication approach is also substantially different, not only because of the specific characteristics of each medium but also in terms of their relationship with the public. *Good Morning Brazil* and *Folha de S. Paulo* broadcast information one-way with little feedback, often with a sensationalist appeal. They support the idea that nanoscience and nanotechnology are harmless and safe, with only a few exceptions. *Nanotechnology Inside Out* seeks to interact with the audience. They use concrete problems of specific groups exposed to potential risks. They discuss the possible controversies and encourage engagement with nanotechnology. They request the opening of new and diverse spaces for scientific communication and public participation. They discuss incorporating new technologies into the media and school curricula.

This comparison leads to the conclusion that science communication on nanotechnology in all three of the media in question are characterized as a tension-filled process in which relevant groups with different projects for science and technology policy, deploy their different amounts of economic and ideological power and use different methods to influence public opinion and public policies for nanotechnology. On one hand, the traditional media groups support the stabilisation of this emerging technology in order to reinforce the interests of (parts of) the scientific community to strengthen relations with the productive sector. In this way, these media are aligned with the central goal of Brazil's nanotechnology policy, which is increasing competitiveness through innovation. On the other hand, the alternative media highlights the interests of another sector of the scientific community and groups of workers and social movements, that expose the flexibility and instability of nanotechnology seeking to influence its orientation, regulation and its inclusion in alternative projects for the economic, social and environmental development of the country.

A similar tension was observed in the Brazilian science, technology and innovation policy during the period analysed. As evidenced by Dias (2012), since the early days of the institutionalization of Brazilian scientific and technological policy, around the 1950s, the research community has remained the dominant actor in defining its agenda. For this reason, even in times of major political, economic or cultural transformations, the pattern of this policy has barely changed. The agenda of a significant part of the research community has continuously remained aligned with the goal of adapting science and technology to the needs of the productive sector. Since the 1970s, technological innovation and university-business integration have gained strength in science and technology policy. However, in the 2000s, the idea gained momentum that the production of technical and scientific knowledge, and especially technological innovation, would be oriented towards a broader strategy aimed at reducing social problems, and towards a sustainable economic and social development. Yet, actions revealed that the latter perspective remained marginal. As a matter of fact, the funding for the research project that gave rise to *Nanotechnology Inside Out*, discontinued after a period of time, was part of this context of valuing new approaches and agendas, enabling the inclusion of new actors such as non-governmental organizations and workers unions in science and technology activities.

Our study showed the predominance of simplistic and limited forms of science communication in Brazilian media. It is necessary to improve the approach of concepts of science and technology, to overcome the naïve, paralyzing and conservative visions of neutrality and autonomy of S&T. In addition, it is necessary to create new spaces for dialogue between the research community and a variety of social actors, with a view to making scientific communication more democratic, which can contribute to fostering a more participatory processes for science, technology and innovation policy making.

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Annex

Table 4. Script for content analysis

Article/Program:	Duration:	Reference Number:
1. Author/interviewee	Institution Academic background	
2. Scientific sources and Institutions cited in articles/programs	National sources/institutions Sources/institutions	
3. Characteristics of the program/article	Brief description Context of program/publication Language and style used: - Scientific explanations - Didactic resources (charts, infograms, images, etc.) - Narratives: fiction, science-fiction, 'before and after' - Metaphors - Comparisons between known and unknown objects Targeted public	
4. Origin myths, definition of nanotechnology and research processes portrayed	Origins of nanotechnology: founders, main breakthroughs and discoveries References to the Drexler-Smalley controversy Definitions used Characterisation as incremental or disruptive technology Research infrastructure and research process Timeline for main applications	
5. Nanotechnology visions	Areas of application Visions on the future nano-society Social, legal and ethical implications Benefits Risks (health, environment, others) Benefit vs risks Normative and ideological content in visions Epistemic, economic and other interests in visions	
6. Brazil's nanotechnology research	How is Brazilian nanotechnology research placed in the global context? Justification for nanotechnology research support Role of nanotechnology research for economic and social development Assessment of Brazilian nanotechnology policy? Main obstacles References to social support or resistance to nanotechnology R&D References to public information and public participation	

Source: Körbes and Invernizzi, partly based on Invernizzi (2008) and Invernizzi and Cavichiolo (2009).