How does the image of the scientist appear in short animation films?

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Abstract

This is a study on the way science and scientists are represented in short films on science and technology featured in Anima Mundi Festival (1993-2013), considering symbolic elements that contribute to the image of science. Amongst 405 films on science and technology, 102 were selected for analysis. Brazilian productions predominated (91), as did films featuring genetics, biotechnology, and astronomy. The narratives mostly address technology development, ethical considerations, and explanations of scientific processes. Scientists appear in 80% of the films – mostly white men, wearing a white coat or uniform, in secret laboratories. Scientists' presence in public spaces – stages, the media, industry – indicates a call for their greater visibility in society.

Keywords: science communication; representation of science and technology; stereotypical scientist; short films; Anima Mundi Festival.

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The image of science and scientists

It is no news that the popular image of the scientist is that of a man with unkempt hair wearing a white coat and spectacles, who is a mad, antisocial genius. Just switch on the television or go to the movies and you will come across scientist characters with these stereotypical features. Science has taken on a central role in society, which is not restricted to the advances and consequences of certain forms of knowledge or their technological applications. The visions of science encompass values, attitudes, and social and cultural practices in the midst of a scientific culture. This all begs a number of questions: how do people construct meaning about science and scientists? How do different media – informative, artistic, scientific – influence, reinforce, or reconfigure this imaginary of science?

This study aims to understand what representations of science and scientists appear in short animation films on science and technology (S&T) shown at Anima Mundi, the International Animation Festival of Brazil, between 1993 and 2013.[1] Studies of S&T in films essentially address four core questions: (1) how the representation of science is constructed in the texts of films; (2) what type and what proportion of science appears in films; (3) what historical and cultural interpretations of science and technology are portrayed in films; and (4) what impacts the representation of science in fictional settings has on the public's understanding of science and their attitudes towards it (Kirby, 2008). Here, we focus primarily on the analysis of the content of films, considering it important to study images of science and scientists without seeing them as knowledge gaps – as in the perspective of the so-called "deficit model" (Lewenstein, Brossard, 2005) – but as indications of how knowledge is generated in our culture and how science and society interact, taking into account mythical, symbolic, metaphorical, and imaginary elements brought into play in the construction of the imaginary of science.

One precursor of this area of scholarship is by Margaret Mead and Rhoda Métraux (1957), who, on studying the perceptions of American students in 1957, found they had a stereotypical idea of the scientist as an older or middle-aged man who wore a white coat and glasses, worked alone in a laboratory, and did dangerous experiments. This stereotype was repeated in subsequent studies of different population groups (e.g., Fort, Varney, 1989; Odell et al., 1993; De Meis et al., 1993).

More recent studies in Brazil show that a high proportion of members of society have a positive take on science. In a 2015 study,[2] for instance, 61% of the respondents said they were interested or very interested in science and technology, while 73% said that S&T brought "only benefits" or "more benefits than ills to humankind." As for the degree of trust felt in different professionals as sources of information on important issues, scientists working for public institutions were held to be the most trustworthy by the respondents. Yet despite these optimistic results, a more in-depth look at Brazilians' attitudes and views towards S&T show that over half identify science as being responsible for most of the world's environmental problems and think that scientists have knowledge that makes them dangerous. The majority also felt it was necessary to set ethical standards for the work of

scientists and that the general public should be able to take part in major decisions about what courses should be taken by S&T.

Scientists in fiction

The images of science and scientists in films, in the visual arts and in literature are related to symbolic, complex, and sometimes contradictory elements, evoking historical and mythical narratives, but also rooted in the impacts of science on society. From Greek mythology, Prometheus is evoked – he who dared steal the fire of the gods and offer it to humanity, contradicting the wishes of Zeus. Described as the myth of modernity, Frankenstein, who appeared first in Mary Shelley's 1818 novel, one of the most widely reproduced images in the universe of fiction, is a shorthand for the fears and angsts of society towards scientific culture. As well as reverberating the imaginary of man as creator, Victor Frankenstein gives birth to a creature who takes his own path, irrespective of his master, and incorporates the image of lack of control and unforeseen consequences underlying scientific research.

From philosophy and the age-old practice of alchemy, the alchemist inhabits the image of the mad scientists who is evil and dangerous, shrouded in mystery and secrecy, who seeks the elixir of healing, immortality, and the creation of the homunculus. Thenceforth we could tick off a series of other references also constituting the social imaginary of science, which reflect concrete and complex relations between science, technology, and society. Probing the origins of the imaginary of science, Castelfranchi (2003) sums up the mythical references that contribute to the formation of this imaginary in three great dilemmas: knowledge as violation, with the allusion to the forbidden fruit of the Biblical narrative, the bravery of Ulysses in his attempt to go beyond the Pillars of Hercules, the outer limits of the Greek world, and the fire stolen by Prometheus; knowledge as power and (lack of) control, which he labels the "sorcerer's apprentice," from *Faust*, by Johann Wolfgang von Goethe (1749-1832), and the passage of the animated film *Fantasia* (1940), produced by Walt Disney Pictures; and knowledge as manipulation and transformation of nature and breaking through the frontier between animate and inanimate, identified in the mythology of Golem and the story of *Frankenstein*.

The way science and scientists are presented in fiction is one of the main influences on public perceptions of these social actors (Pansegrau, 2008). In an analysis of western literature until the twentieth century, Haynes (2003) draws attention to the constant presence of the stereotype of the mad, evil, dangerous man associated with the figure of the scientist, arguing that good-natured scientists appear as a minority and that a handful of stereotypes recur in literature and film, from which he picks out seven main types. Nonetheless, in an analysis of films and novels since the 1990s, Haynes finds a change in the representation of scientists, where this stereotype is replaced by more humanized characters with concerns more geared towards family, relationships, friendships etc. (Haynes, 2014).

Weingart (2006) analyzes the visual image of chemistry and the chemist in 222 feature films from eight decades, highlighting symbolic elements of alchemy in the characterization of the character. One key characteristic that sets alchemy apart in modern science is its secrecy. The most prominent feature of the mad scientist in films is the secret lab furnished with gothic features from medieval castles. Secrecy is also portrayed in images of the modern laboratory, which is often labelled with a sign indicating its private nature, and which is only inhabited by one individual or the scientist and their assistant.

Kirby (2008) makes a retrospective of topics and areas of knowledge that galvanized the symbolic repertoire in films in the twentieth century. At the beginning of the century, X-rays and electricity became a key focus of the big screen. Chemistry became a feature in representations of science after World War I, which historians of science call the "war of the chemists," where science, state, and military apparatus are seen to intertwine. In the 1950s, physics and especially nuclear energy dominated the backdrop of films. Space science also appeared in this period, such as in the science fiction movie *Destination Moon* (1950), by Irving Pichel. In the 1970s, driven by Richel Carson's literary work *Silent Spring* (1962), the environment took over as a key element of the narratives. Biomedical science and nanotechnology are central in films from the 1990s onwards, and several films have influenced the cultural meanings of genomics and genetic engineering, like *The Boys from Brazil* (1978), *Jurassic Park* (1993), *The Island of Dr. Moreau* (1996), and *Gattaca* (1997).

Female scientists appear less often than male scientists, and rarely have the same features. In an analysis of 60 feature films from 1929 to 1997, Flicker (2003) not only found a predominance of male scientists, but also found the typical portrayal of the female scientist to be a professor with specific physical attributes: young, pretty, athletic, and wearing provocative clothing. When they are part of a team, they are generally subordinated to men. The author argues that this representation contributes to the development of myths about women scientists' inferior competence and reinforces the social discrimination of women in science.

Animation and science

Dexter in his laboratory, Professor Utonium, "inventor" of the Powerpuff Girls, the super-villain Dr. Heinz Doofenshmirtz in *Phineas and Ferb*, Professor Gearloose in the Walt Disney cartoons, the inventor Flint Lockwood in *Cloudy with a Chance of Meatballs*, the laboratory rats *Pinky and the Brain*, *Sid the Science Kid*, and a great many others are some examples of how stereotypical the depiction of scientists in cartoon series and feature films is. Merzagora (2010) argues that stereotypes enable audiences to recognize the character of the scientist more easily, which means producers do not have to spend a whole lot of time developing the character. However, this recourse is accentuated in the language inherent to the construction and planning of characters in animation movies.

In her analysis of *Dexter's Laboratory*, *The Powerpuff Girls*, and *The Adventures of Jimmy Neutron*, Siqueira (2006) points out how Dexter's interests in his laboratory work are strictly personal. The young scientist also perpetuates an experimentation-oriented model of science, involving glassware, test tubes, pipettes, and electronic equipment. In all three

series, scientists work inside their homes in secret labs. Mesquita and Soares (2008) also note how similar Dexter and Jimmy Neutron are: both are male children who work in isolation in their laboratories and think they are cleverer than everyone else, which exempts them from doing commonplace activities like tidying up their rooms or fixing things around the house.

Studying comic strips, Will Eisner raises an important discussion in *Fagin the Jew* about the recognition of the impact of stereotypes on social judgment. However essential a tool they are for comic strip and cartoon narratives, Eisner criticizes the stereotypical Jew constructed by Charles Dickens in *Oliver Twist* for helping to "reinforce the stereotype that racists have placed on Jews throughout history" (Eisner, 2005, p.24). He puts forward a stereotype closer to reality in the understanding that fictional characters can become lasting stereotypes and influence the way these groups are seen by the rest of society.

In the field of education and science communication, animation films can be used to present concepts and phenomena in a compact format and represent dynamic processes that are invisible to the naked eye both on a micro- and a macro-scale. They can simultaneously express visual, verbal, and aural narratives, they can include interactive media, and they can be enjoyable and have emotional appeal. As an object of study, animation works with stereotyped images and metaphors, proving a good tool for the analysis of the imaginary of science (Schummer, Spector, 2007).

In the context of authorial or independent animations, the animator has greater freedom to explore and invent their own means of signification in the conception of films as processes of communication, creating new languages in the film universe (Graça, 2006). These are spaces of greater autonomy in the poetic process of the development of singularity, breaking down the rules underpinning mainstream practices. Short films are the most widespread format for authorial animation films. In Brazil, animation festivals are the forums where animation movies – especially shorts – have the chance to be seen in parallel with films distributed along traditional channels. They reach a diverse audience and are taken to different regions of the country, even if most are still seen in the south and southeast.

Organization of the study

The purpose here is to understand how science and scientists are portrayed in short films presented at 21 editions of Anima Mundi (International Animation Festival of Brazil), from 1993 to 2013. Anima Mundi is the biggest animation film festival in the Americas and the second largest in the world, attracting around 80,000 people every year. It gives an overview of Brazilian and international animation film production, especially the independent scene, with the aim of promoting animation in its most plural and diverse forms, valuing the inclusion of films from different countries using different animation techniques, employing a variety of narratives, and investigating diverse subject matter.

The festival does not have one particular section devoted to science films per se. As such, based on the titles and synopses in the festival catalogue, four criteria were used to select which ones to sample: (1) direct mention of the terms science, scientific, scientists,

research, researchers, or academics; (2) mention of scientific terms; (3) presence of spaces for the communication of science; (4) educational and/or classroom material. For the film to be included in our corpus, it had to meet at least one of these criteria.

The decision to analyze only short films was taken since this is one of the most important formats for animation films, giving animators greater artistic freedom in view of their limited commercial value. This is a film format where the animator can experiment with new ways of doing animation, storytelling, and developing aesthetics and formats. It is also an important space for the renewal of animation language, having repercussions in the commercial circuit, often serving as a pilot for subsequent larger-scale application in a feature film or series (Faria, 2015).

Based on the aforementioned selection criteria, 405 films addressing science and technology were retrieved. All these films were then described in general terms before a second selection was made for a more in-depth analysis. In this second stage, the films that were originally selected under criterion number (1) were retained, since these were the ones that were more directly related to science and technology. A good many of the films are available online on different websites, mostly YouTube and Vimeo. The films not found online were viewed at the festival's head office.

In the analysis, the protocol developed by researchers from the Ibero-American Network for Monitoring and Training in Science Journalism – Rede Cyted (Ramalho et al., 2012) was used, which was itself based on a tool developed by Bauer, Ragnarsdóttir, and Rúdólfsdóttir (1995).

The original protocol covers seven dimensions – general characteristics, relevance, theme, narrative, treatment, actors, and location – which are then split into several categories. Taking the animation movie as a unit of analysis, we maintained, with some adaptations, the dimensions "general characteristics," "theme," "narrative," and "treatment," while highlighting certain categories previously covered under "treatment" to create a new dimension, "scientists," so that we could analyze the physical attributes, stereotypes, and mythical elements associated with the scientists depicted in the films (Table 1).

Table 1: Dimensions and categories used to analyze the content of animation movies with a science and technology theme

General characteristics	Number in the catalogue
	Name of festival
	Year of festival
	Session of festival
	Title
	Director
	Year of production of film
	Nationality
	Duration
	Synopsis
	URL of film (if available online)

Topic	Keywords
	Main area of knowledge
Scientists	Presence of the figure of the scientist
	Type of scientist
	Sex of scientist
	Place where scientists appear
	Age of scientist
	Skin color of scientist
	Physical attributes of scientist
	Symbols of research
	Symbols of knowledge
	Indications of danger
	Indications of secrecy
	Mythical and literary references
	Characteristics of scientists (Long et al., 2010; Steinke, 2011)
	Classic stereotypes (Haynes, 2003)
Narrative	Framing
Treatment	Does the film explain a scientific term or concept?
	Does the film address controversies (scientific or other)?
	Does the film mention any concrete benefits of science?
	Does the film mention promises of science?
	Does the film mention concrete damage caused by science?
	Does the film mention potential risks of science?
	Does the film make recommendations to the viewer?
	Does the film offer information about the context?
	Does the film presence science as a collective activity?

Source: compiled by the authors.

The categories "physical attributes of the scientist," "symbols of research," "symbols of knowledge," "indications of danger," and "indications of secrecy, were based on the Draw-a-Scientist Test (DAST) checklist (Finson, Beaver, Cramond, 1995), which sums up the elements found using the DAST checklist described by Chambers (1983) and used to research public perceptions (particularly on the part of children and youth) of scientists by asking them to do drawings of scientists. The "narrative" dimension of the analysis covers the concept of the framing of the films, which is the "central organizational ideas that provide a context and suggest what problem is to be addressed through criteria of use, selection, exclusion, and elaboration" (Ramalho et al., 2012). The concept of framing used in the protocol stresses the use of the frames and the selection of certain aspects of perceived reality. It highlights the meaning of context, understood as the effect of selecting certain aspects of perceived reality and its resulting focus in a communication piece (Entman, 1993).

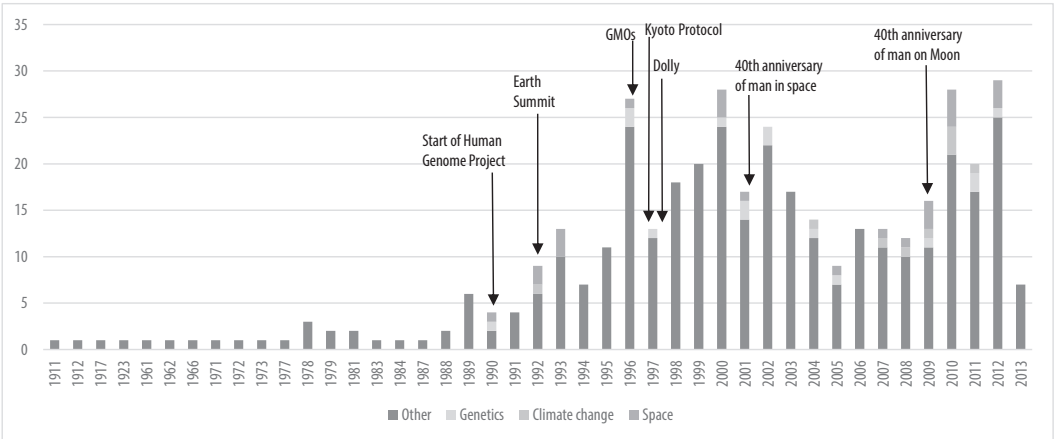
Here, we present the analysis of some of the general characteristics of the films, like nationality and year of production, as well as the main subject matter and areas of knowledge covered, their framing, the presence of scientists, and the settings in which they appear in the films.

Characteristics of the corpus of films on science

From an astronaut facing an existential crisis to a robot-inventing girl; from a documentary about pre-historic Earth to laypersons asking childish questions about the human body to a post-apocalyptic world dominated by genetically modified (GM) plants. The scientists include shamans, witches, alchemists, men, a few women, one black man, biologists, geneticists, astronomers, physicists, archaeologists, and historians. The animation techniques include 2D, 3D, acetate, stop motion, hand-molded figures, paper figures, archive images and the films portray a diversity of subjects and characters. The films addressing science and technology accounted for an average of 5% of all the films shown at each of the festivals. However, as a proportion of Brazilian films, they account for more: 9% of all the Brazilian films had subject matter that was related to science and technology.

Most of the films that make it to the festival are produced in the same year or one or two years previously. However, when there are special screenings or guest filmmakers or when studios feature important films from their trajectory, the production date may be much older than the year of the festival. This is why films produced up to the mid-twentieth century are also included (see Graphic 1). We can see that 2012 (29), 2000 (28) and 2010 (28) were the years when most animation movies on S&T were produced, followed by 1996 (27) and 2002 (24). The films that gave more than one year for their production were classified under their post-production year. Two of the films did not have a production year identified in the catalogue.

Graphic 1: Films screened at Anima Mundi according to their production years (n=405), featuring films addressing genetics, climate change, and space



Source: compiled by the authors.

Our analysis draws attention to the existence of films addressing emerging topics like biotechnology, genetic engineering, climate change, and space science (Graphic 1). The landmarks involving the consolidation of the fields of genetic engineering and biotechnology are reflected strongly in the films. Even if debates about GM organisms began in the 1970s in the academic sphere, they only became more general knowledge in the mid-1990s, when Monsanto obtained approval from the EU to export GM soybeans to its member countries, in 1996. This was when boycotts and protests against the growing and selling of GM crops started to be organized, especially in Europe (Almeida, 2012). Alongside the heated debate about GM organisms, in 1997 there came the announcement of the first successful cloning of a large mammal from an adult cell, resulting in Dolly the sheep. The 1990s also saw the beginning of the Human Genome project, galvanizing thousands of scientists and laboratories the world over with the goal of mapping the human genome. Led by two independent fronts – one public and one private – the international consortium divulged the results of the undertaking in February 2001: the public consortium's version on the front cover of *Nature* and the version of the company Celera Genomics in *Science* (Salzano, 2012).

Several films were identified that discussed topics like DNA, genetic manipulation, GM organisms, Dolly the sheep, the theft and selling of human organs for transplant etc. The earliest such film in our corpus is John Weldon's *To Be*, from 1990, the year when the Human Genome project research was started. *To Be* tells the story of a scientist who invents a machine that can copy physical objects, including people, sparking ethical dilemmas that involve the possibility of creating a copy of oneself.

There are three films from 1996 and 1997 that discuss genetic manipulation: *DNA* (Italy, 1996), *ADN* (1996), and *Hello, Dolly* (Brazil, 1997), a short by Daniel Schorr produced and shown in 1997, part of the series *O ano 2000 em 2000 frames* (The Year 2000 in 2000 Frames).

A new wave of films on genetic engineering and cloning comes between 2000 and 2005, with titles like *Moving Illustrations...* (2000), which shows a mechanical world in which human eggs are genetically reprogrammed by machines, and *(R)evolution* (2001). From 2009 to 2012, there are films on transmutation, a scientist involved in human cloning to meet market needs, and transnational agribusinesses that promote the growing of GM crops and displace family farmers.

When it comes to the image of science and scientists, in the films addressing topics from biotechnology and genetic engineering, the characters who are scientists are predominantly mad, evil, dangerous, inhuman, socially isolated, and involved in experimentation on animals and human beings, doing science in their own private laboratories. The main thrust of their narratives is the moral and ethical dilemmas of research. This stereotype is similar to the one described by Haynes (2003) as being hegemonic in western literature, with symbols that speak of the image constructed around practices of alchemy.

The environmental theme, especially climate change, appears in the sample as of 1992, starting with the film *Stop the Greenhouse...* (1992), a music video about the greenhouse effect geared towards the youth audience. The same year witnessed one of the first ever international conferences on climate issues, the United Nations Conference on Environment and Development, or the Earth Summit, in Rio de Janeiro. Another landmark in the area was the Kyoto Protocol, adopted at the third Conference of the Parties (COP3) in Japan

in 1997, by which developed countries undertook to reduce their CO_2 emissions by 5% by 2012, taking their 1990 emissions levels as a reference, entering into effect in 2005.

In 2004, the term "global warming" started to appear, such as in *Filme Ilhado* (2004), which tells of the despair of a shipwreck and the consequences of the greenhouse effect; *Global Warming* (2007), a musical satire sung by a character who does not believe in the effects of global warming on the planet and invites everyone to sing along with him; and the Brazilian film *Buba e o Aquecimento Global* (2009).

Space science is present throughout the whole period, from 1990 on, with reference to astronauts, aircraft, and rockets. The films considered under this topic also include ones that deal with astronomy. In the films on space, although there are very varied characters, the overwhelming narrative is that of scientists as explorers of new worlds, involved in space adventures. The year 2001 marked the fortieth anniversary of man's first voyage into space. On board the spacecraft Vostok 1, the Soviet cosmonaut Yuri Gagarin became the first man to go into orbit outside the Earth's atmosphere. In 2009 came the fortieth anniversary of man's arrival on the Moon. The space race and its characters are mentioned in several films produced in periods near commemorative dates, like *Gagarin* (1993), *Yuri Gagarin* (2000), *Explodium* (2001), *Moon Seek* (2007), *Project Alpha* (2009), and *Return* (2009).

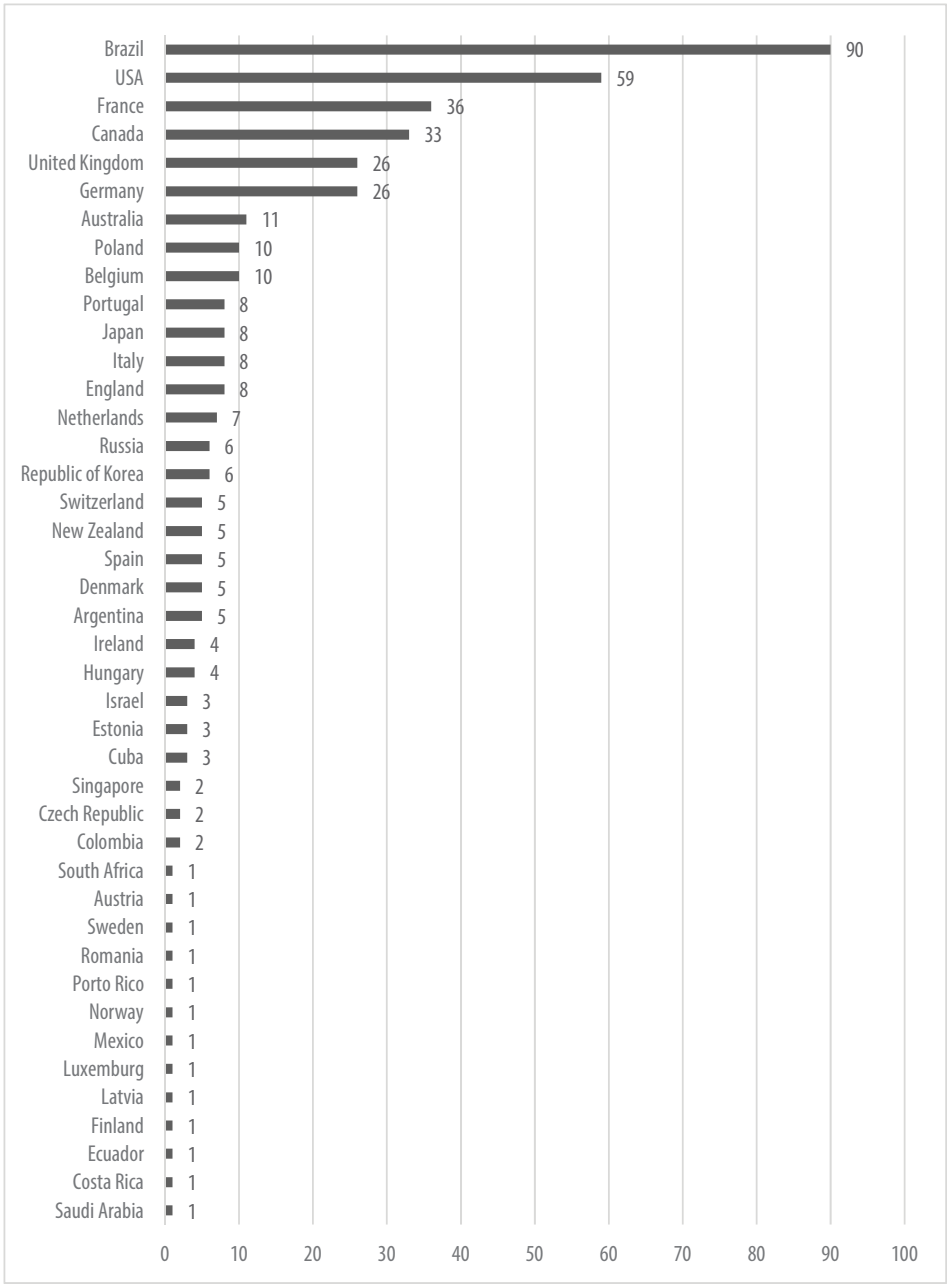
Nationality of the films

Brazilian authors lead the production of films on science (22%; 91 films). As the festival is Brazilian and has the stated goal of fostering national animation, it features Brazilian films with specific screenings and special guests. However, this fact alone does not explain the number of Brazilian films dealing with science, since many of them were exhibited in competitive sessions, competing on an equal footing with foreign productions. The second biggest producer was the USA, followed by France, Canada, the UK, and Germany (Graphic 2).

Principal area of knowledge

We selected 102 films to analyze the dimensions "topic," "scientists," and "narrative." This more detailed analysis included all the films in the corpus that make direct mention of the terms science, scientific, scientists, research, researchers, or academics. Of the 102 films analyzed, 44 addressed science and technology in general terms without devoting themselves specifically to one area of knowledge. Nineteen films covered subjects related to the exact and earth sciences, 11 to the life sciences, seven to medicine and health, and six to engineering. The humanities (five films) environmental sciences (four), and linguistics, letters, and arts (one) were present in fewer films. The fact that around half the films fitted into the category of "science and technology in general" demonstrates how many of the films interact with different areas of knowledge. Films featuring natural scientists are also included in this category, since natural history has to do with a time when scientists were generalists and developed knowledge about different fields of knowledge. In the exact and earth sciences, the main topics covered are astronomy, physics, chemistry, and mathematics. In the films on the biological sciences, the areas of evolution and genetic engineering stand out.

Graphic 2: Country of production of the films shown at Anima Mundi (n=413)



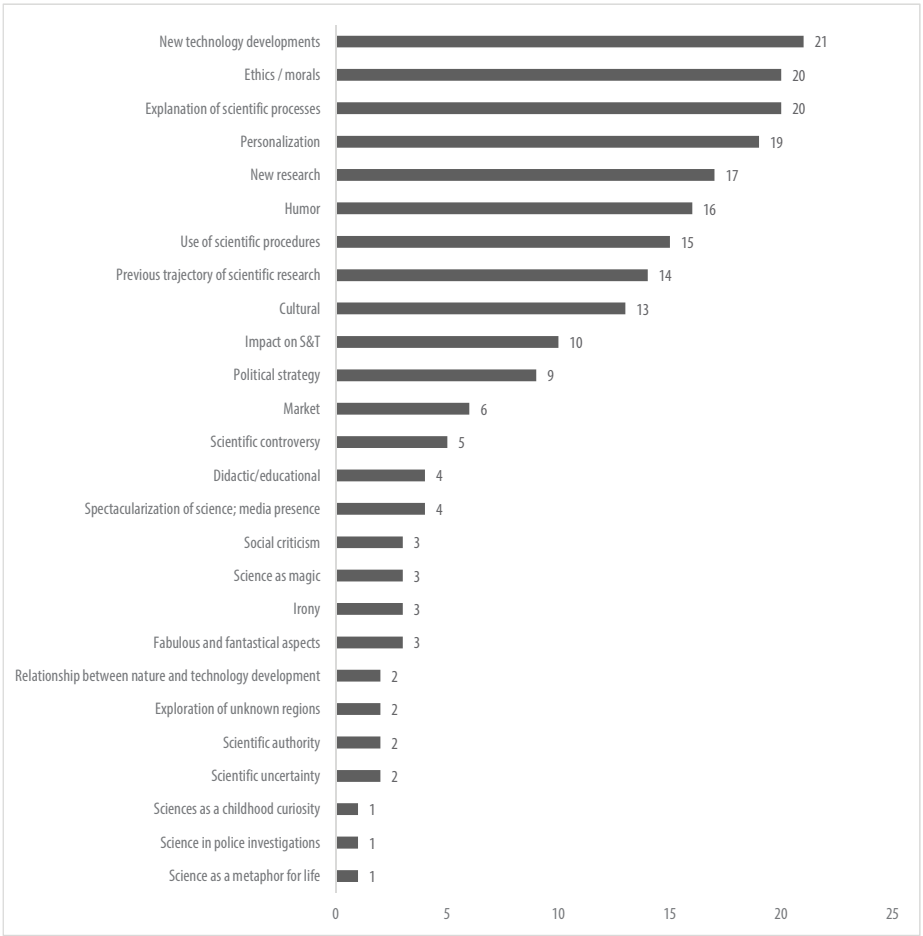
Source: compiled by the authors.

Framing

Four principal narrative themes stand out in the films analyzed: "new technological developments," present in 21 films; "ethics/morals," in 20 films; "explanation of scientific processes," in 20 films," and "personalization," in 19 films (Graphic 3). The first of these

appears mainly in films with inventor scientists, whose narratives include the production of machines, inventions, and robots with practical purposes. Four of these are Brazilian and three revolve around the figure of Santos Dumont, his inventiveness and importance to the history of aviation. "Ethics and morals" appears as a key theme in films that address subjects like genetic manipulation, pesticides, and the transformation from non-living into living, which have to do with the myth of Frankenstein and Golem. Ethics and morality in research appear as central when the scientist's behavior is inhumane and when the research goals are questionable. The stereotype of the inhumane, socially isolated scientist is described in several studies (Haynes, 2003; Weingart, 2006) and appears in the short films analyzed. In four of the shorts, scientists use human guinea pigs in their experiments, such as *Les Ramoneurs...* (2002), in which a group of scientists drill into the brain of an individual tied to a chair, introducing small creatures in order to brainwash him, or *Kann ich...* (2000), where the scientist does an experiment on a man in a bathtub with his body covered with electrodes (Image 1).

Graphic 3: Framing encountered in the selected films shown at Anima Mundi from 1993 to 2013



Source: compiled by the authors.

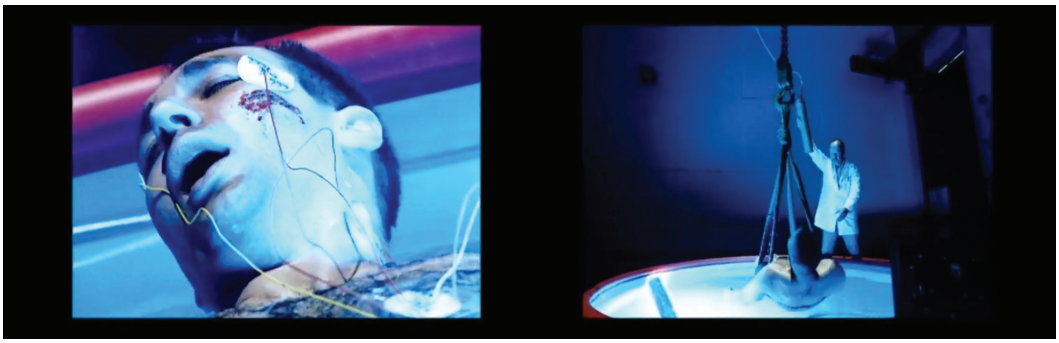


Image 1: Experiment on human beings in *Kann ich was abhaben?* (2000)

Research based on dubious, self-serving interests is seen here in the films whose main narrative thrust is of an ethical/moral nature, in line with the findings of other studies of animations (Siqueira, 2006; Mesquita, Soares, 2008). Two such examples are *Homem Planta* (2011) and *Animalário* (2012), which show mad, greedy scientists doing experiments with the aim of earning fame and success. At the end of both films, collections of dead animals in bottles, the outcomes of unsuccessful experiments, are seen.

Nine of the 20 films which deal, amongst other things, with the "explanation of scientific processes" are episodes of science communication series. When it comes to the figure of the scientist, in 11 of these films, scientists per se appear, while in eight there are no scientists depicted, and in just one does the figure of an inventor appear. Nineteen films also contain explanations of scientific terms, including *Por que os animais...* (2012), *Rockstar...* (2012), *Rupestre* (2009), and *Paultje...* (2008).

In *Rockstar e a Origem do Metal* (2012), a teenage rock star lifted onto a periodic table guides the viewer through a lesson on basic concepts of chemistry and astronomy in a quest to understand the origin of heavy metals like iron. The speech and images (see Image 2) work together to give explanations of the concepts: "Let's begin with the simplest atom: hydrogen. This atom's nucleus has just one proton. Add a neutron and we have deuterium, an isotope of hydrogen ... the combination of these nuclei [deuterium, tritium, and helium] forms other elements, but that only happens inside stars, like the Sun."

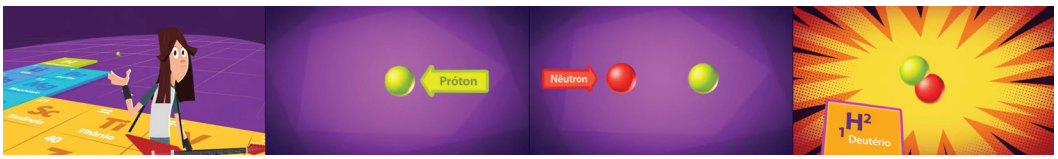


Image 2: Scenes from *Rockstar e a origem do metal* (2012)

In *Paultje en de draak* (2008), a boy is diagnosed with cancer and, after doing some exams, the doctor attempts to explain to him how the treatment works (Image 3). His first idea is to show where the cancer is in his body, how the medicines work, and what procedures are necessary. But when he realizes that this explanation just frightens the boy even more, he decides to make up a story using the dolls the child has taken to hospital with him – a

knight in armor and a dragon. The dragon becomes a metaphor for the cancer, while the boy, with the help of blue and white creatures – in an allusion to the cells that defend the body – becomes the knight. He fights against the dragon and overcomes the ailment. One curious thing about this film is that it does not contain any verbal language; all the symbols and metaphors are expressed through images alone.

Image 3: Scenes from *Paultje en de draak* (2008)

Humor is an artifice characteristic of the language of animation, and in the analysis it emerged as one of the key aspects of 16 of the films, even if many of the others also used it, too. Another typical feature of animation and fiction films is the presence of characters as central elements of the narrative, which explains why the frame "personalization" appears in so many of the films.

The presence of scientists in the films

The figure of the scientist appears in 78% of the films. These figures were then broken down into the subcategories of scientist (60%; 61 films), inventor (15%; 15 films), explorer (2%; 2 films), and wizard (1%; 1 film). The first subcategory contains a whole gamut of characters (Image 4), including astronauts, astronomers, geneticists, biologists, mathematicians, archeologists, sanitarians, doctors, naturalists, historians, physicists, chemists, taxidermists, paleontologists, and meteorologists. The films with inventors have scientists who create machines and inventions with practical applications.

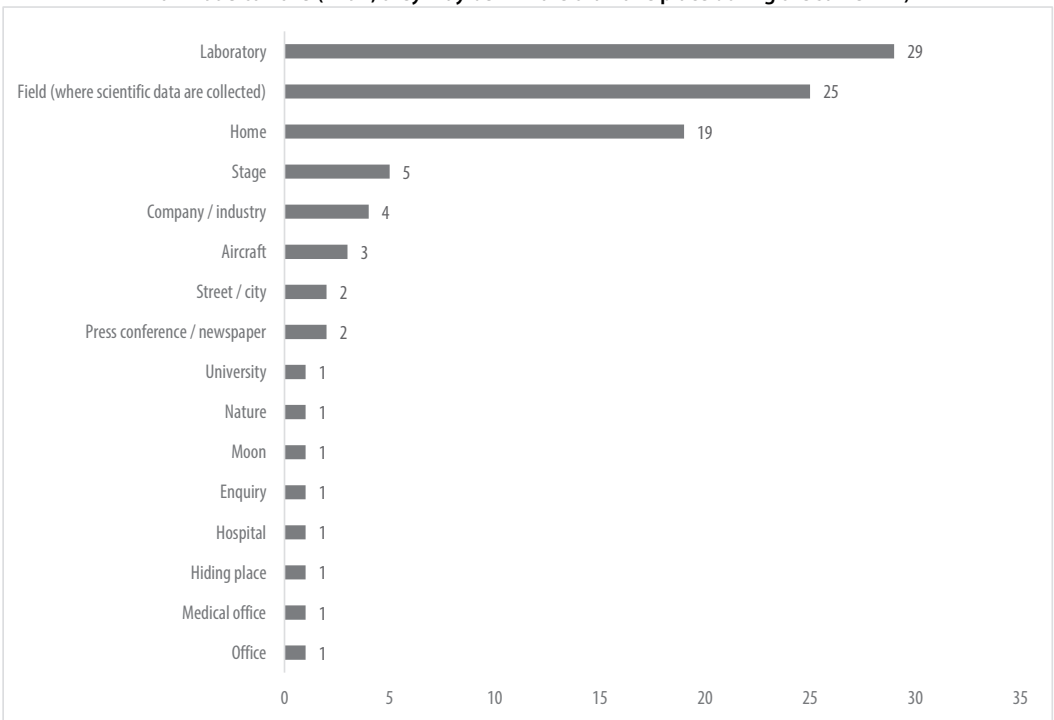
Image 4: Images of scientists in the films (1) *To be*; (2) *Paralaxe*; (3) *14 Bis*; (4) *Masks*; (5) *Lifeline*; (6) *The Aeronaut*; (7) *Emilie*; (8) *Cebolas são azuis*; (9) and *Stopmo*

There is a marked difference in the presence of male and female scientists. Male scientists account for 89% of the scientists who appear in the 79 films with these characters, while female scientists make up just 13% (10 films). As for the total number of scientists in each film, 78 male and 10 female scientists were identified in all, and in only two films were scientists of both sexes present. As for the scientists' age, the majority were adult (67%; 53 films), followed by old (20%; 16 films), children (3%; 2 films), and youth (just 1 film). The age of the scientists in nine of the films could not be ascertained. As for apparent skin color, as expected, most were white (80%) and in only one film was the scientist black. In 14 films, it was not possible to identify skin color and one film was in black and white.

Location of the scientists

The laboratory was the place where the scientists appeared most in the animated films under analysis (37%; 29 films), followed by the field (32%; 25 films) – i.e., involving the scientists collecting data for their research – and then their homes (24%; 19 films) (see Graphic 4 and Image 5). In many of the films, the scientists' laboratories were set up in their homes, in which case their location was classified as being at home. Other less common places for the scientists to do their work were aircraft, press conference, university, moon, hospital etc. One feature associated with the scientists' locations, especially their homes and laboratories, was that they were in isolated places, hidden, or high up, such as in the penthouse of an apartment building or on the peak of a mountain, amongst trees and foliage or surrounded by a graveyard.

Graphic 4: Places where scientists appear in the films selected from Festival Anima Mundi, from 1993 to 2013 (n=97; they may be in more than one place during the same film)



Source: compiled by the authors.

Image 5: Images of places where scientists appear in the films (1) *Dr. Fly: Engolindo Sapo*; (2) *The Wolfman*; (3) *Ursa Minor Blue*

In five of the films (6%), the scientists appear in front of the public, such as on stage or in a theater. In *To Be* (1990), for example, a scientist sends out invitations to residents for them to watch a demonstration of his new invention – a machine that creates copies of physical objects, including people, which he does on stage at a technology fair. In voiceover, the narrator says that residents were "invited by an eminent scientist to demonstrate his most recent invention," and the scientist announces this invention as "a new form of transport that will bring great benefits to humanity." In four films (5%), the scientist appears in industrial facilities or companies, like *Masks* (2011) and *More* (1998) (see Image 6).

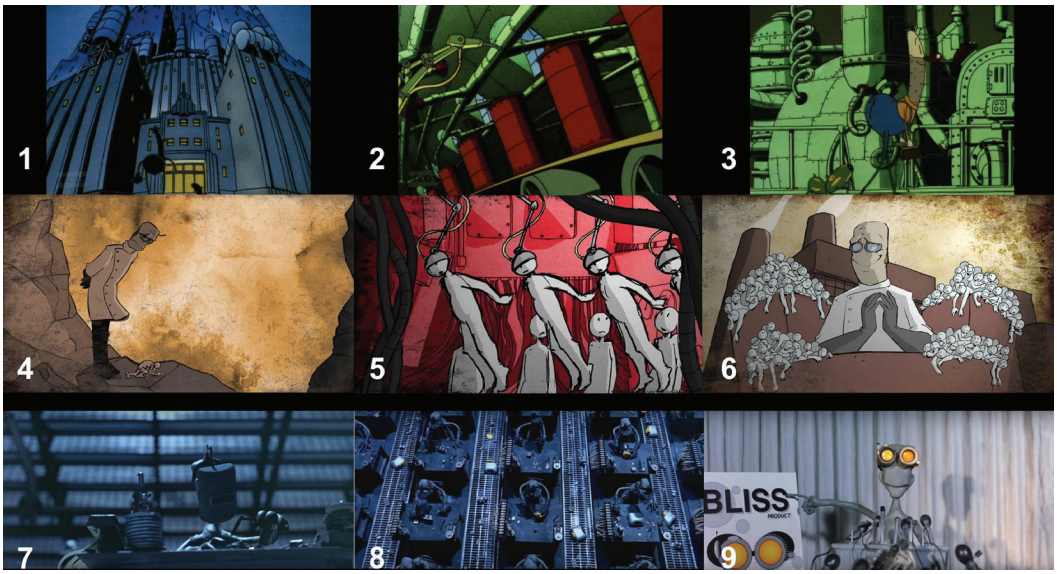


Image 6: Stills from films in which the scientist appears in an industrial setting: (1-3) *More*; (4-6) *Nightwatchman*; (7-9) *Masks*

Two of the representations are noteworthy for the place where the scientist appears. If the presence of scientists in their lairs or in laboratories in their homes conjures up images of science as a secret, individual, dangerous practice with questionable objectives, alluding to the image of the alchemist (see Weingart, 2006), the appearance of the scientist in public places, like stages, in the media, at press conferences, and in business and industrial settings, is indicative of a new representation for the scientist, who not only no longer acts in isolation from society, but actually attracts attention to himself before society. This new form of representation seems to reflect the role scientists take within the whole modus operandi of technoscience, at the intersection between science, technology, and neoliberalism (Castelfranchi, 2008). According to Castelfranchi, in technoscience the roles of the scientist are more varied and different, insofar as they can act simultaneously as professors, administrators, researchers, project leaders, military advisors, private consultants etc. He sees the emergence of the role of the entrepreneur-scientist as a sign of the functioning of technoscience in neoliberalism. In this ambit, the scientist invests in his human capital as a businessperson, and science is produced, assessed, and generated within the logic of economics. Castelfranchi also indicates the importance of communication, and a whole network of actors operating as communicators, including scientists, under this new paradigm.

Final considerations

In this study we have investigated animation films to reflect on the repertoire of meanings and images that have an impact on the imaginary of science and scientists. In the 21 years of Anima Mundi under study, films addressing science and technology are

a constant, accounting for 5% of all the films screened, on average. Scientists appear in almost 80% of the films analyzed, mostly in the form of white male adults, around half of whom wear a white coat or some sort of uniform. Alongside these elements, a whole host of other characteristics are attributed to the scientists in the films, especially medical devices and bodily abnormalities. Science is mostly portrayed as an activity undertaken by individual geniuses in isolation, being depicted as a collective activity in just 11 of the 102 films analyzed. Gil-Pérez et al. (2001) comment that this individualist, elitist view of science is linked to an empirical idea of "discovery" and contributes to a decontextualized, socially neutral interpretation of what science is.

Unlike previous studies of the representation of scientists in films (Weingart, 2006; Pansegrau, 2008), which feature the figure of the chemist, the madman, the evil, dangerous scientist, or the eccentric nerd, the films analyzed here contain a broader diversity both in terms of area of specialization and the scientists' behavior. The films contain biologists, geneticists, astronomers, physicists, archaeologists, historians etc., and feature scientists who are inventive, intelligent, clumsy, and media-savvy. The classic image of the mad scientist locked away in his lab still appears, but more associated with areas of biology involving genetic manipulation and cloning than chemistry, as described in the literature review, even if the films still hark to the universe inhabited by the image of alchemy.

Although a private lab is still a major presence, there are scientists depicted in public places, like stages, in the media, at press conferences, and in business and industry settings, which is indicative of the scientist winning over more visibility for him/herself in society. It is also curious how certain themes that emerge in the films are directly related to events and debates that circulate in the public arena, like cloning, GM organisms, climate change, and space science.

Women scientists are notable for their underrepresentation in the films, corroborating the findings of other studies (Chimba, Kitzinger, 2010; Long et al., 2010; Whitelegg et al., 2008), as well as the way they are represented. There are films that portray the exclusion of women from scientific practices and institutions, like *Miss Todd* (2013); films that expose how sexist biases influence the representation of scientists, like *Rocket Science* (2006) and *Homem Planta* (2011); and films that reconfigure the image of women as protagonists of science, like *Emilie* (2012).

One key focus of the narratives of the films is the explanation of scientific processes, which is one of the criteria considered by León (2008) as fundamental for the good coverage of science, alongside the contextualization of scientific practices, which also appears in these films. We believe that a contextualized view of science and the recognition and understanding of the social nature of science are important elements for a more appropriate representation of the nature of science. The absence of such elements is categorized by Gil-Pérez et al. (2001) as one of the problematic, distorting visions of scientific work.

The procedure adopted in this study gave the opportunity to make a more detailed analysis of films where scientists appear, but had certain limitations when the figure of the scientist is not present. This can be seen in six of the 102 films selected for analysis, because not only do they not depict scientists, they also do not obviously fit into any of the pre-set categories, like "symbols of research," "symbols of knowledge," or framing. The

procedure used here served to pick out specific elements of scientists and science, but not an aesthetic analysis of the films or their narratives, even if the frames give some clues as to the narratives they adopt to discuss science-related topics. The aesthetics and narratives of the films in question deserve more in-depth analysis in future studies.

One important reflection that emerges from the study is the interest it identifies on the part of Brazilian animators to produce films about science, given that around a quarter of the films selected at the festivals were made in Brazil, and many were shown at the competitive screenings – which is indicative of their quality. One way to gain a more nuanced understanding of the representations of science in these animation films would be to analyze the motivations, trajectories, and interests of the directors and the factors involved in their production.

The choice of films to analyze was restricted to the scientific content they portrayed, which meant that dimensions such as production and conception by directors and reception by different audiences were not picked up. Ramalho (2013, p.190) draws attention to the limitations of analyzing S&T aspects in a particular medium in isolation, since it offers a limited perspective, insofar as "the meaning of a text is not an inherent characteristic of that message, but open to different interpretations by different audience groups." As such, one possible ramification of this work could be to look into how they were received and try to note how different audiences construct meanings about the images we have analyzed.

The films propose worlds, reinvent worlds, and expand our knowledge of the world, ways of living, and historical periods. They do not just fascinate or embellish, but also disturb, cause discomfort, put us in other people's shoes, and in other realities and contexts. Thinking of films as experiences (Xavier, 1983) leads to the idea of them getting under our skin, the feelings they awaken in us and the emotions they spark. The films selected here are not of one type; rather, they are accounts of ideas and thoughts of people from different parts of the world, but perhaps share precisely this capacity to prompt new experiences and engage viewers emotionally.

In this analysis, we took a descriptive route, highlighting certain elements in the films' content, especially their representations of science, such that the experience upon watching them and the cinematographic resources are given little attention in the analysis. Yet when we think of the ways these films could be exploited, their potential as aesthetic and political experiences must surely be taken into account. One of their strengths is as educational resources, and not just in formal settings. Fresquet and Migliorin (2015, p.17) highlight the power of films in school to transform teaching practices: "Between the world represented and the creation engaged in a work, cinema contributes to the intellectual emancipation of the teacher and the student, an emancipation directly linked to the inventive potential of cinema." Furthermore, school is a place where "it is possible to invent ways of seeing and being in the world that can upset a given order, what is established, places of power" (p.8), attributing a critical, political, and subversive role to film in education.

Passed in 2014, Brazilian law 13.006 requires schools to screen two hours of Brazilian films per month as supplementary activities tied in with the school's curriculum. Mapping out films on various themes from science, as was done here, could help teachers and educators meet this hard-won requirement, while also further developing filmmaking in education.[3]

A number of studies have looked into the existence and use of audiovisual materials in science teaching (e.g., Marandino, Selles, Ferreira, 2009; Rezende Filho, Pereira, Vairo, 2011). One of the views that has gained currency in studies of the area is a focus on such resources for educational purposes (Rezende Filho, Pereira, Vairo, 2011). One criticism of this approach is that it subordinates the potential of film and audiovisual materials to another area of knowledge, making it more likely to be considered merely illustrative and not necessarily capable of intensifying teaching and learning processes. Duarte (2002) stresses the educational nature of film, seeing both education and film as aspects of culture that produce knowledge, identities, and subjectivities. In a study of reception, Rezende Filho et al. (2015) have looked at students as viewers and agents in the production of meanings of films and videos, not just passive observers. Marandino, Selles, and Ferreira (2009) argue that the media penetrate school not just on the initiative of teachers, but in the students' own relationships and cultural baggage, as they talk about the movies, videos, and television programs that inhabit their daily lives. The authors suggest that media and their uses should be resignified and recontextualized in the school setting: "School and educators are, in this perspective, subjects in this process of recontextualization, by resituating media and its content in a specific context, with its own aims, meanings, and specificities" (Marandino, Selles, Ferreira, 2009, p.175). As for the way science is represented in such material, a critical interpretation is called for in order to "question the communication of myths, naturalizations, representations, spectacularizations of nature, simplifications ... whether at the time of the choice of the materials or during their use and elaboration with the students" (p.184).

By studying scientific culture and the complexity of symbols, myths, contradictions, and stereotypes of scientists present in art, we hope to help build a greater comprehension of the representations of science and technology and to foster dialogue between the fields of science and art.

NOTES

[1] For more details on the study and to consult the complete table of films analyzed in this study, see Reznik (2017).

[2] For more on the Brazilian survey, access <http://percepcaocti.cgee.org.br/>.

[3] For an analysis of the requirement for Brazilian films to be shown at Brazilian schools, see Fresquet (2015).

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