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Notes on Scientific Cinema: Arlindo Machado

Apontamentos sobre o Cinema Científico: Arlindo Machado

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Abstract: Arlindo Machado made films and wrote articles about a type of cinema scarcely debated by the communication field, called the "science cinema". This article discusses his ideas on the subject, articulating concepts and historiography about the origins of cinema by using his writings on pre- and post-cinema. The dialog with his works suggests questions about the invisibility of science cinema, pre-cinematic machines, and their relationship with science, as well as Brazilian cases of science films. Based on the elements discussed, we speculate on the possibility of composing a language that goes beyond the mere recording of images. At the end, we discuss the aesthetics and ethics of the attractive realism of medical images and their repulsive aspects, as well as the completeness simulacrum of today's astronomical images.
Keywords: science cinema; pre-cinema; invention; medical images, astronomy.

Resumo: Arlindo Machado realizou filmes e escreveu artigos sobre um tipo de cinema pouco debatido pelo campo comunicacional chamado "cinema científico". Esse artigo discute suas ideias sobre o tema, articulando conceitos e a historiografia sobre as origens do cinema por meio de seus escritos sobre os pré-cinemas e os pós-cinemas. O diálogo com suas obras sugere questões a respeito da invisibilidade do cinema científico, das máquinas pré-cinemáticas e suas relações com a ciência, além de casos brasileiros de filmes científicos. A partir dos elementos abordados, especula-se a possibilidade de composição de uma linguagem que ultrapasse o mero registro de imagens. Ao final, discute-se sobre a estética e a ética do realismo atraente de imagens médicas e seus aspectos repulsivos, assim como sobre o simulacro integral das imagens astronômicas dos nossos dias.
Palavras-chave: cinema científico; pré-cinemas; invenção; imagens médicas, astronomia.

Introduction

"Scientific cinema has more future than you think." With this sentence, Arlindo Machado ends his article on scientific film, published in 2014 in the journal *Significação* (MACHADO, 2014, p. 28). The phrase, which recalls the well-known sentence attributed to Louis Lumière about the future of cinema, also implies that scientific cinema is not present in the collective imagination. There are many reasons for such an assertion, after all, it is neither recognized by specialists as a film genre nor a consolidated field of research. Arlindo Machado (2014) himself states that "this is a topic that is little or nearly not discussed in the fields of film theory, criticism and historiography" (p. 15).

Arlindo Machado made two scientific films in the 1970s: *A influência do álcool nas atividades psicomotoras* (*The Influence of Alcohol on Psychomotor Activities*, 1978) and *Sistemas dopaminérgicos cerebrais* (*Brain Dopaminergic Systems*, 1979), in partnership with the Escola Paulista de Medicina (EPM). He also directed the film *Cubatão transfigurada* (*Transfigured Cubatão*, 1981) along with Irene Machado, a short film about environmental degradation. The latter, despite suggesting science, is an experimental work of an artistic nature, with images that denounce the pollution of the city associated with social issues of youth. In a more recent context, it might fit in some scientific film festivals that are more and more concerned with environmental issues and more open to daring audiovisual proposals.

When presenting his personal experience with scientific cinema, Machado recounts his first two works in partnership with EPM's (Escola Paulista de Medicina) Psychobiology department and highlights aspects of the interest and commitment of the group from both fields – cinema and science – to the theme explored. He recognizes that scientific films cannot be a commissioned institutional work, like an advertising piece hired by an audiovisual professional. The filmmakers must study the subject as much as possible to understand the scientists' challenges and design special devices for each situation. In the case of *Sistemas dopaminérgicos*, "special close-up lenses and boxes with one glass wall" were developed to perform the filming. In this way, the cinematographer is also an inventor who thinks the cinematic machine beyond its *ready-made* nature.

However, despite promoting a very active participation by filmmakers, scientific cinema attracts limited interest in the field. The most significant publications on the subject are almost always related to research on the early cinemas, the improvement of cameras, and the construction of the cinematographic language. Despite the authors'

efforts, there does not seem to be a very clear circumscription that it is a field or a film genre. In the Anglo-Saxon universe, there are few courses and departments related to the theme, few specializations and disciplines that promote scientific cinema. Examples such as the University of Southern California (UCS), which maintains a microscopic imaging discipline in the Cinematic Arts course under the supervision of psychologist and computer scientist Richard Weinberg, are rare. Most of the experts on the subject are professors in technology and humanities departments, such as Jean-Baptiste Gouyon at University College London (UCL) and Oliver Gaycken at the Maryland Institute for Technology in the Humanities (MITH). In fact, few academic journals address the topic internationally. One of them, Public Understanding of Science (PUS), founded in England in the 1990s in partnership with Imperial College and the Science Museum of London, publishes 80 to 100 articles annually, but in its total collection of over 20 years, only 58 articles are related to cinema. The journal aims to bring together academic research on science, regardless of the disciplinary affiliation of the researcher, to contribute to public understanding of it. What can be observed is that there is a more well-defined field of research on science dissemination and, within it, few elements of scientific cinema.

On the other hand, in the case of France, a certain idea of scientific cinematography is more integrated into the history of the country's cinema, in which its characters are mixed in the field of invention. This relationship can be found in the critic and theorist André Bazin's words, who states that, "when Muybridge and Marey made the first scientific research films, they not only invented the technology of cinema but also created its purest aesthetic. For this is the miracle of the science film, its inexhaustible paradox" (BAZIN, 1947, p. 145).

Figuring in this tradition are not only Muybridge and Marey, but also the father of *time lapse* microscopy, Jean Comandon, and the filmmaker of the biological world Jean Painlevé, an author who made the paths of sea creatures and surrealism cross. With the French, spirochetes, liquid crystals, fungi, gut microbes, urchins, and octopuses were able to get their movie star versions on the screen. One of the important elements of Comandon and Painlevé's experiments is the possibility of making the invisible visible, through inventive adaptations of film cameras remodeled as visualization instruments. Comandon attached his camera to microscopes, produced special environments for his shots, as did Painlevé, who built a special glass device for his water shots. Through these explorations, we, the viewers, are seduced by the exciting curiosity about the world that inhabits us and the one we inhabit but which we are unable to perceive with our natural senses.

Before them all, astronomer Jules Janssen had developed a photographic device called a "revolver," which resembled a cannon, to obtain images of the phenomenon known as the transit of Venus, which occurred in 1874 (Figure 1). An international team led by Janssen went to Nagasaki, Japan, where the phenomenon would be optimally visible. A Brazilian astronomer, Francisco D'Almeida, was in charge of obtaining a plate with several photographs of the edge of the sun that would be set in motion in order to verify the distance between the Earth and the Sun. Thus, the astronomer Janssen also qualifies as a precursor of cinema, his device being considered the "first scientific cine camera" (TOSI, 2005, p. 39). Joseph Leclerc, in the documentary *Le cinéma au service de la science* (*The Cinema at the Service of Science*, 1945), states that Janssen would have created the astronomy cinema and Comandon, the microscopy cinema.

Figure 1: Images of the transit of Venus

Aiming to consolidate a space of its own, the Institut de cinématographie scientifique (ICS) was founded in 1930, with the participation of Jean Painlevé. At the time, the institute ventured to elaborate a categorization for a possible scientific cinema with three classifications: research films, science popularization films, and educational films. Research films are those that magnify invisible details, making micro- and macroscopic phenomena visible, or capturing the image of a fleeting phenomenon, for example. Science popularization films, on the other hand, spread the understanding of some complex subject, without being didactic like educational films, which are used to illustrate or complete a course. Assuming that it is difficult to obtain a clear distinction between "science films" and "technical films," the institute regrets in advance the difficulty of categorization, since many films could fit into different qualifiers. Even today, part of this discussion is found at science film festivals in an attempt to organize the material they receive and will present to the public. At that time, ICS would find in Jean Painlevé the inspiration

for the integration of the two worlds, for "specialized references and filmographies will become necessary for serious scientists, just as bibliography is essential for authors who wish to publish without incurring the reproach of their predecessors" (PAINLEVÉ, 1956, p. 32).

Arlindo Machado also risks articulating the integration between the two universes and presents the filmmaker as a scientist, or, at least, someone who knows how to fit into the knowledge requested by scientific research. This definition resembles more recent thinking, such as that of scholarr Jean-Baptiste Gouyon, who refers to the filmmaker as an "equal partner and reflexive creator of science" (GOUYON, 2015, p. 2). It is interesting to note the fear of the filmmaker – and of cinema in general – of becoming just a supporting actor in the relationship. At a given moment in the article, Arlindo Machado mentions the anthropologist Margareth Mead precisely for the perspective of thinking of photography and cinema not only as means of documentation of anthropological research, but as "catalyzing elements of revealing experiences in the field of human relations" (MACHADO, 2014, p. 17).

A fear, but also an aspiration for a particular participation in the path of science. To qualify such productions, Machado says that the result usually is not produced as a traditional film, with opening credits and introductions, sophisticated editing, and soundtrack. Science films are made with the purpose of being presented in scientific environments for discussing the results or phenomena visualized, and are "*works in progress*, which evolve along with the research" (MACHADO, 2014, p. 18). This aspect can be seen from the very beginning in the films of Jean Comandon, for example, who, in 1909, filmed for the first time the bacterium that causes syphilis, at that time still called *Spirochaetta pallida*, later categorized as *Treponema pallidum*. The film *Syphilis spirochaeta pallida* (1909) was part of his doctoral thesis about a disease that at the time had no cure and was considered the "third great plague". Comandon's very powerful microscope could produce oblique illumination with the "dark field" technique, making microorganisms visible and illuminated in a particularly cinematic setting. The American newspaper *The New York Times* announced the event with the headline "Microbes caught in action" (MICROBES..., 1909). After this event, Charles Pathé and his collaborators invited Comandon to microscopic-cinematographic sessions at the studio in Vincennes, where they were able to record and project, using the cinematograph, the then invisible universe (EPSTEIN, 2019). For years, Comandon produced his films at the Pathé studio and later at the Pasteur Institute, with rudimentary card presentations, no end credits and very little editing elaboration (LEFEBVRE, 2012). Even in 1929, although Jean Comandon's film

La croissance des végétaux (*The Growth of the Plant*, 1929) features some editing with explanatory cards and a clock to reinforce the notion of time, it remains a science presentation piece. Comandon is just one example that could be extended to the chronophotographic films of Marey and Lucien Bull.

In the case of Brazil, science cinema has a rather hesitant trajectory. Despite the Brazilian participation in Janssen's cinematic experiment, in 1874, our astronomer Francisco Antônio D'Almeida did not scientifically disclose his participation, and we only know about it through the French. The mission to Japan was much criticized in Brazil, with allegations that it was unnecessary for a country with so many social problems. Emperor Dom Pedro II was mocked by the magazine *Illustrada*, a satirical abolitionist publication that claimed that the emperor lived with his head in the clouds and Brazilian scientists were just "carriers" of instruments (ALMEIDA; SILVA; SUPPIA; STALBAUM, 2017). According to astronomer Rogerio Mourão, the subsequent astronomy mission in 1882 achieved a very accurate measurement of the solar parallax, and both 1874 and 1882 missions were considered positive by the scientific community (MOURÃO, 2004b), just as Janssen's short film proved to be very productive for the field of astronomy.

From a more general point of view, science film emerged in Brazil in the 1910s, with initiatives for scientific dissemination, such as the Roquette Pinto Foundation. There are also records of films made about the fight against yellow fever by Instituto Oswaldo Cruz, in 1911 (OLIVEIRA, 2006). Arlindo Machado calls attention to the most successful Brazilian example of science cinema: Benedito Junqueira Duarte, an award-winning photographer and film critic in São Paulo newspapers who made science films between the late 1940s and the early 1970s. Duarte became known outside the field because of the filming of the first Latin American heart transplant, performed by surgeon Euryclides Zerbini, in 1968, which received great attention from the Brazilian media at the time (BRAILE; GODOY, 2012).

As registered in the Cinemateca Brasileira database, Benedito Junqueira Duarte's first science film is called *Apendicectomia* (*Appendectomy*), and was made in 1949 (SILVA, 2020). It is a short film, 35 mm and black and white – with neither references nor metadata. In total, the Cinemateca Brasileira database contains 261 references to Duarte's films, and assuming from the titles, 204 have a "scientific" character[2]. For Arlindo Machado, Junqueira Duarte "is a *sui generis* case", for despite

[2] Benedito Junqueira Duarte comments having made more than 500 science films on the subjects "of medicine, surgery, biology, genetics" (DUARTE, 1970, p. 34). Márcia Regina Barros da Silva reports that in his abbreviated biography there are 227 films (SILVA, 2020).

having had a vertiginous career as a photographer, filmmaker, film critic and political activist, he made, according to himself, more than 500 films (DUARTE, 1970) (Figure 2). B. J. Duarte presented his science films internationally and received awards for his cinematography at the Nantes International Medical Film Festival (1968) and the British Science Film Festival (1964), as well as several "Surgery and Medical Film" awards in Rome in 1966, 1968 and 1969 (DUARTE, 1970). All this production has been carefully studied by historian Márcia Regina Barros da Silva, with an extensive list of publications about the filmmaker and his films.

Figure 2: B. J. Duarte filming the surgery performed by Euryclides Zerbini
Source: Duarte (1970).

Furthermore, Arlindo Machado demonstrates how film theorist B. J. Duarte was a pioneer in articulating his practice with the theory, arguing that, in the 1970 article "O filme científico", the author "risks a rather daring hypothesis: that science cinema was the first cinematic 'genre' in the history of this medium and, more than that, it was the genre that engendered the basic technology of what we now call cinema" (MACHADO, 2014, p. 20). This is precisely the thesis of Italian researcher Virgilio Tosi, in *Cinema before Cinema*, written in the 1990s, an expanded version of publications from 1977 on. Another work that presents similar ideas is Laurent Mannoni's *Le Grand art de la lumière et de l'ombre : archéologie du cinéma (The Great Art of Light and Shadow: Archeology of Cinema*), written in 1994, in which the author presents the phantasmal shadow machines as precursors of cinema, based on

their approaches to scientists surrounded by charlatans. Both publications are later than B. J. Duarte's, who traces an archeological overview of the science film quite similar to that of Tosi and Mannoni, but more concisely. In it, Duarte (1970) considers surgical and medical films in general as "branches of science cinema" (p. 38).

In the history of French cinema, a rather peculiar character also filmed surgeries: Dr. Eugène-Louis Doyen. The surgeon acquired a camera to film his surgeries as soon as he saw one of the Lumière Brothers' exhibitions. In order to instruct students who would hardly have access to the surgical theater room, Doyen films numerous surgeries very closely, the most famous being the separation of the Indian conjoined twins Radica and Doodica, who were already *freak show* curiosities (BAPTISTA, 2005). Even today, in the 21st century, the rawness of filmed surgeries makes the eyes of the contemporary audience close, even those accustomed to the bloody horrors of the violent films of recent years. Doyen's films ironically got out of his control and were sold for showings in *vaudevilles* and circuses in several European countries in the early 20th century. According to Thiago Baptista, an opportunistic collaborator named Ambroise-François Parnaland, would have been responsible for the screenings that would stain the surgeon's reputation and lead him to ban the screening of his films. Only later, after they were compiled as *Film conferences*, was the showing of the films allowed by Doyen (Figures 3 and 4), highlighting that they were accompanied by text readings (BAPTISTA, 2017).

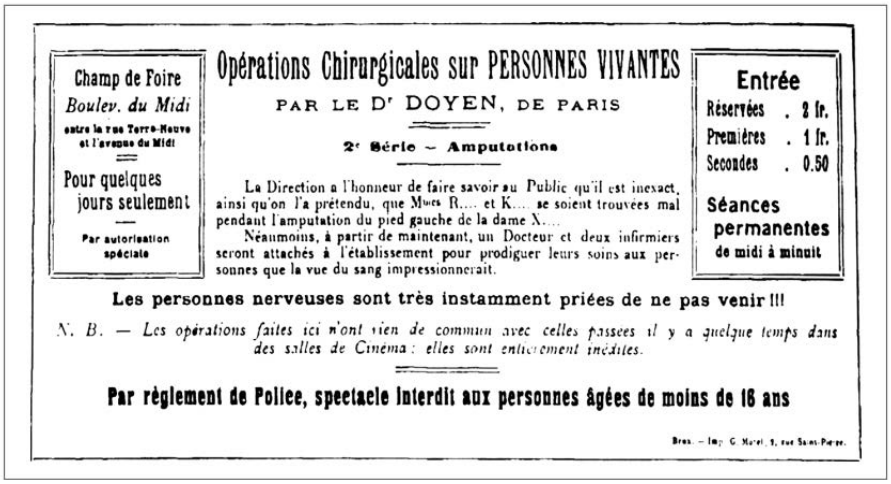

AVISO IMPORTANTE

Segunda feira 1 de Junho em sessão extraordinaria ás 11 horas da noite apresentar-se-ha uma fita scientifica dedicada á classe medica e estudantes de medicina cuja fita consta de varias operações d'alta cirurgia feitas pelo celebre operador francez Dr. Doyen.

Previne-se o publico que algumas d'estas operações são de tal realidade que não é conveniente que aquella sessão (11 horas da noute) assistam senhoras e muito menos creanças.

Bilhetes sem distincção de logar 100 réis

Figure 3: International Congress of Medicine and Surgery, 1906, Lisbon.
Source: Baptista (2017).



Champ de Foire
Boulev. du Midi
entre la rue Terre-Neuve et l'avenue du Midi

Pour quelques jours seulement

Par autorisation spéciale

Opérations Chirurgicales sur PERSONNES VIVANTES

PAR LE Dr DOYEN, DE PARIS

2e Série — Amputations

La Direction a l'honneur de faire savoir au Public qu'il est inexact, ainsi qu'on l'a prétendu, que Mmes R.... et K.... se soient trouvées mal pendant l'amputation du pied gauche de la dame X....

Néanmoins, à partir de maintenant, un Docteur et deux infirmiers seront attachés à l'établissement pour prodiguer leurs soins aux personnes que la vue du sang impressionnerait.

Entrée
Réservées . 2 fr.
Premières . 1 fr.
Secondes . 0.50

Séances permanentes
de midi à minuit

Les personnes nerveuses sont très instamment priées de ne pas venir !!!

N. B. — Les opérations faites ici n'ont rien de commun avec celles passées il y a quelque temps dans des salles de Cinéma : elles sont entièrement inédites.

Par règlement de Police, spectacle interdit aux personnes âgées de moins de 16 ans

Figure 4: Doyen film advertisement
Source: Androutsos, Diamantis, and Vladimiros (2008).

Baptista, director of conservation at the Cinemateca Portuguesa, was responsible for supervising the restoration of Doyen's most complete collection in Lisbon. He relates the curious myth that the Doyen films would have caused those who were able to watch them to faint, which he believes is a case of "archival terror" (BAPTISTA, 2017). Another interesting example about the reception of these films is that of a recent screening in Luxembourg to rescue the place where they would have been exhibited 100 years before. Taking on the anguish caused by the films, the curators decided to hand out vomit bags to the audience, in addition to promoting a debate about the ethics of the spectacularization of the medical image and the "excess of reality" of the scenes (BERTEME; DAHLEN, 2012). What is referred to here regarding the "excess of reality" is a specific type of scopic relationship of the eye that negotiates its attraction with the rawness of the body image of scientific-biological origin, a movement that repels and attracts at the same time.

This is a complex debate that finds some resonance in the effects of the aestheticization of the image. In the case of B. J. Duarte, it is the details of the exhaustive procedures of aesthetic composition that attract attention. He states that science film should not abandon the artistic for its didactic concerns and warns that science filmmakers tend not to care about aesthetics because they assume that technical fidelity is sufficient for the task. He maintains that the "scientific" should not avoid the "artistic," because it is possible to create a "dramatized atmosphere" with "functional lighting." Detailing the procedures of the experiment, Duarte writes:

> If a film about surgery requires a fidelity of color which is indispensable to the information and logical development of the theme, if in a film about abdominal surgery it is necessary to obtain all the shades of red and blue contained in the cavity, from the purplish of the gallbladder, from the brownish of the liver, to the pink of the gastric pouch, streaked by the bright red of the arteries, or the densest of the veins which irrigate it. If it is indispensable to obtain this chromatic objectivity, there is nothing to prevent the camera operator, with functional lighting, from dramatizing this faithful set of colors and hues, creating in his work the very atmosphere, so highly dramatized of an operating room. (DUARTE, 1970, p. 38)

For Duarte, the use of two-color gloves, blue-colored medical uniforms, gauze pads, and compresses can help achieve dramatic color compositions. However, color composition, which is a usual concern of the arts and cinema, becomes disturbing in the surgical context. The realism of human organs achieves a certain brutality in the color adjectives, leading to a malaise of comic effect.

The aesthetics of the scientific film

Without going to a stylizing extreme, some aesthetic concerns are also found in Arlindo Machado's words when he describes his own experiences with science films: clean environment, better visualization in terms of light and framing, proximity of the cameras, the capture of natural sounds. In *A Influência do Álcool nas Atividades Psicomotoras* (1978), with script and direction by Arlindo Machado, it can be observed that the didactic concern is the dominant axis of the film. The elegant framing, with positioning of the objects and actors with harmonious and classic proportions, takes turns between the more distant shots and the closer ones that describe the objects mentioned in the narration. Without compromising didacticism, the suspenseful soundtrack of the film's opening is a counterpoint of stage objectivity. CET psychologist Gilda Freitas Dias and Sérgio Tufik, professor at Escola Paulista de Medicina, are the narrators of the experiment in which an actor (with no specific description in the signs) submits to the research processes in a passive way, evidencing the objective character of science (Figure 5). There are attractive visual contributions, such as the cutting of the simulation situations from the tests with game cars, aimed at motor acuity as opposed to real cars on the road, as well as animations with graphics that clarify the results obtained with other research groups, anticipating today's computer visualizations.

Figure 5: Images from the film *Influência do Álcool nas Atividades Psicomotoras* (1978), with Professor Sergio Tufik.

Source: A Influência… (1981).

The other film, *Sistemas Dopaminérgicos Cerebrais* (1979), is much bolder from the start. Directed by Arlindo Machado, the script was elaborated in partnership with professor Tufik and photographer José Roberto Sadek. In it, the actors are the mices. Without ceasing to be didactic, the initial shots, after the opening, with two yellow canisters occupying the black background enunciate a formal concern that points to the primacy of the cinematic visual domain. What is at stake in the film is paradoxical sleep-in mammals and the effects of its deprivation – achieved through drug induction. Although the result is intended to be a model for the human, only human hands are present in the film. Along with objects, instruments and mices. The experiment goes on, and as the sleep-deprived mices are doped, they become aggressive and fight inside their cages until they bleed out. This capturing trap for the human eye by the over-reality of science images is particular to the genre (or supposed genre). As commented earlier, the same effect occurs with Doyen's filmed surgeries or the numerous films by B. J. Duarte that show human organs taken out of their contexts. In the case of *Sistemas Dopaminérgicos* mices, the proximity of the animals in a clean scene is obtained by a camera that reveals them in an eerily familiar way. Even without having any particular resemblance to men in body shape, it is impossible not to see, in those rodents, boxers fighting to exhaustion.

Science cinema contaminating cinema

The year after Machado's film, French filmmaker Alain Resnais released *Mon oncle d'Amérique* (*My Uncle from America*, 1980), a film incredibly contaminated by science and which shows two mices fighting in shots very similar to those of *Sistemas dopaminérgicos*. The film presents at length the theories of French surgeon Henri Laborit with images of objects and animals, showing various aspects of neurophysiology, including the biography of the doctor himself and his studies on the brain. Focusing on elements of action and inhibition of it with its forms of escape, such as aggression, Laborit enters the scene in his laboratory as the narrator of his theses. He thus introduces the fictional characters on which his analyses develop in film form. In this case fiction is used to clarify Laborit's theses on brain physiology through three characters who will face challenges in their lives, presenting different answers. The modular film in game form also becomes a film about cinema, as French cinema scenes are introduced in the characters' moments of decision. Illustrating the characters' behaviors, scenes with real mices in "Skinner boxes" are shown from their responses to each stimulus and the punishments they receive. In an allusion to the cohabitation of couples, when the mices are placed together in the box, they fight like boxers (Figure 6).

The two films together are a curious coincidence, comprising distinct but similar universes regarding the way in which the film machine and its historicity are conducted. Resnais' film has a lavish production, with renowned actors such as Gérard Depardieu and Roger Pierre, and was awarded at the Cannes Film Festival. Machado's film is a scientific experiment, obscure as that kind of filmmaking has been treated. There is no possible comparison in their proposals and perspectives, but there is an incredible visual coincidence by the interest in the mices anthropomorphized by the camera (Figures 6 and 7). Perhaps therein lies the unseen future of scientific cinema.

Figure 6: Images from *My Uncle from America*
Source: Mon oncle… (1980).

Figure 7: Images from the film *Sistemas dopaminérgicos*
Source: Systems… (1979).

Arlindo Machado may have perceived a future for science cinema by the fact that he enunciated it in his writings about cinema's past. Without the central point being science, Machado gathers, in book form, materials that he had produced in different research about the ancestors of cinema, with the designation "pre-cinemas". In the book published in 1997, this content was divided into two parts, the "origins of cinema," in which he reflects on Reynaud, Robertson's phantasmagoria spectacles, Marey and Muybridge's decomposition of movement, and Plateau, and the "cinema of origins," which has been called primitive cinema or early cinemas. *Pre-cinemas & post-cinemas* is a landmark book by a generation of communication, cinema, and media researchers which has the foresight to associate the production of the origins of cinema with the production of contemporary film and video.

By introducing the visual devices preceding the birth of cinema, Machado warns that science men, "positivists by formation, such as Marey and Londe, only ever got interested in the first part of the cinematic process, the analysis/decomposition of the movements into frozen instants, seeing no scientific interest in the next stage, the synthesis/reconstitution of the movements by the projection in the darkroom" (MACHADO, 1997, p. 19). The same would be true of Muybridge or Janssen, both interested only in the first part of the process. Other encounters, such as those of Méliés and Lumière with machines – in addition to the imaginary of charlatans,

illusionists, curiosity seekers, and artists – that built what is known as cinema. Continuing this debate, Machado (1997) elaborates the question: "could one speak of an incompetence of science to account for cinema as a phenomenon?" (p. 21). His answer is that cinema was invented "in the dark," by trial and error. Assuming that the invention of cinema is intrinsically connected to scientific experiments, Joseph Plateau is the scientist who pursues the underlying question of the invention of cinema machines by trying to understand the phenomenon of retinal persistence. Plateau, with his device, the phenakistoscope, believed that the illusion of image movement was due to an image fixed on the retina that filled in the interruptions made by the rays of the disc, joining successive drawings. However, Machado (1997) warns that "the phenomenon of retinal persistence has nothing to do with the synthesization of movement: it constitutes, in fact, an obstacle to the formation of animated images, since it tends to overlap them on the retina, mixing them together" (p. 20). Thus, what "saved the cinema as a technical apparatus was the existence of a black interval between the projection of one frame and another, an interval that allowed the attenuation of the persistent image that was retained by the eyes" (MACHADO, 1997, p. 20). In other words, science would not have been able to create a language with the machine like cinema did. As a consequence, would this mean that science cinema would be fated to register phenomena and not build its own language?

The futures of science cinema

Going back to the sentence that started this article, why then would one not "think" about a future of this type of cinema, with such a curious and engaging past? One can assume that science cinema has also been repressed by the narrative model in force after David Griffith, according to the thesis of the relationship between pre-cinemas and post-cinemas. In other words, the creative cinemas prior to Hollywood cinema (Griffith as the axis of this cinema) were lost for years and were only "liberated" by new technologies such as video and digital film. Following such reasoning, this would be one of the reasons that would also make pre-cinematic science films "invisible" in the eyes of critics and historians. In this way, the rescue of such films takes place precisely with the connection between the two periods, in an attempt to understand the scientific films that were produced before the "films", so to speak. What is "thought" in Machado's sentence would be related to his non-recognition during a certain time in which the way of thinking about cinema is modeled by a certain thought about what cinema would be. Tom Gunning, a leading historian on the origins of cinema, in writing the introduction to Mannoni's book, states that

"cinema is only part of a broad visual culture that lies at the intersection of modern science and modern media" (GUNNING, 2000, p. xxx).

About the future of science cinema, it is coherent to think that Machado understands that the possibilities released by the new media for production and public dissemination can launch new perspectives, also because of the diversity of languages and formats. For him, *Powers of ten* (1977), by Charles and Ray Eames, and the BBC television series *Supersense* (1988) are examples of more recent productions of the intersection between film and science. The camera's *zoom in* and *zoom out* capabilities are applied to demonstrate the perceptual logic of micro and macro so familiar to scientists in the case of *Powers of ten*. In the case of *Supersense*, Machado argues that intersemiotic translation is the operation performed to demonstrate the animal senses to an audience of humans with their five natural senses in front of an audiovisual screen. More appropriately, according to him, a case of biosemiotic translation leading to a friendly process of relating to animals through communication instead of training (MACHADO, 2014). Even though both films use advanced technological resources, it is the ability to construct film languages that can translate the elements of science. But each language construction, such as editing features within the frame to show the sharks' scopic field, is a response to a challenge posed by science.

It may be that part of Arlindo Machado's interest in the subject of science cinema, besides a rescue about his personal experiences in the field, would be precisely that of resuming the ritual of invention. His experiments with science give him the opportunity to invent and adapt machines in a subversive, almost "Flusserian" way, to quote an author dear to Machado. Unfortunately, I could not find pictures of the filming at Escola Paulista de Medicina, but the glass-walled boxes mentioned in the article remind us of iconic images in the historiography of scientific cinema, such as those of Painlevé making his films. Machado, in an article about the work of German filmmaker Alexander Kluge for television, elaborates a vision coherent with his position about cinema as a way of thinking, starting from the instruments:

> The thinker of today is no longer a stubborn intellectual, sheltered in their office, they no longer sit at their desk, beside their books, to give shape to their thought, but build their ideas using new tools – camera, editing island, computer –, invoking other thought supports: his collection of photos, films, videos, records – his media library, etc […] Understanding the contemporary world is no longer something that can be practiced only with verbal language. Rather, it is something that results from a radical attempt towards a full audiovisual thought, built with images, sounds and words that combine into a higher order unit, of a more complex level. (MACHADO, 2007, p. 87)

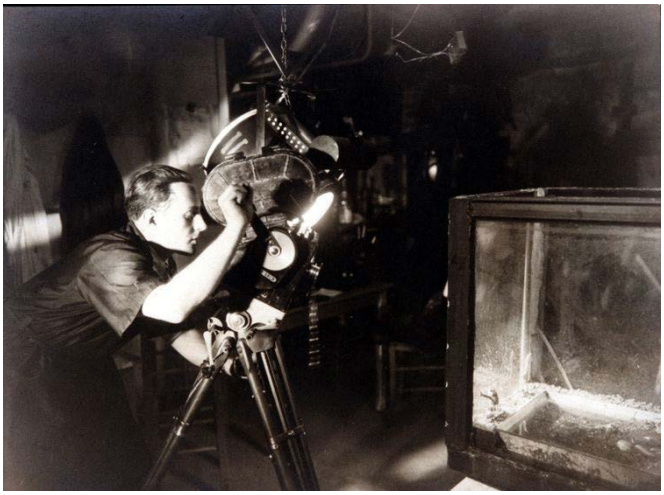


Figure 17: Jean Painlevé filming
Source: Alchetron[3].

To conclude, two other particular points of scientific cinema: the excess of images and the excess of reality. Machado, closing his article, evokes the "*imagerie*" of laboratories and hospitals, whose excess makes you have the impression of being in a futuristic movie theater. Despite its generosity about the problem, too many such images cause complex and adverse reactions. Some images of a "scientific" nature clamor for our attention on free websites, like a contemporary version of *freak shows*. They usually escape the domain of science, either deliberately or by carelessness. Or they were simply made using available imaging technology and the proximity of the body. Without our being able to avoid it, one wrong click brings forth an abject world before our eyes. But abject to whom? After all, they multiply precisely because they attract. Again, the *voyeur* attraction and voyeur repulsion of a certain scientific image (and its "inexhaustible paradox") have the same materiality that inspired debates about the limits of representation in cinema.

Arlindo Machado's futuristic movie theater bears more resemblance to the images of the astronomical sublime, with glows and attractive effects produced by today's computer animation that develops an integral simulacrum that acts as the counterfield in small science films of the 21st century. This, by the way, is a subject that I would have liked to have had the opportunity to discuss with Arlindo: the realism of scientific animation.

[3] Available at: https://bit.ly/3G1pw0w. Accessed: Jan 5, 2022.

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