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This dossier is dedicated to the memory of Josep Miquel Vidal (1939-2013) promoter and heart of the Spring School.

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SCIENCE ON TELEVISION: THEORY MEETS PRACTICE. AN INTRODUCTION

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"Science on Television" was the topic of the "7th European Spring School of History of Science and Popularization" that was held in May 2013 in Maó, Minorca, Spain. "Science on Television" seems to be a fascinating subject. It deals with the communication and circulation of scientific knowledge in contemporary societies. Television has been and still is an extremely influential mass media and has the power to shape our ideas of science, medicine and technology. Yet what exactly are we to study? News programs, magazines, edutainment shows, science documentaries, movies, series, advertising – the variety of different TV genres that explicitly or implicitly deal with science is as broad as television itself. And how are we to study it? Approaches vary from a purely textual analysis of television pieces to a fully-fledged contextualization of the science and media processes of their production and consumption.

Studies about "Science on Television" have repeatedly dealt with the "eternal" tension between the meanings and purposes of education, information and entertainment. They have addressed the relationship between the processes of production and management of scientific knowledge and the general public, focusing on issues such as accessibility, literacy,

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accuracy and general interest (Long & Steinke, 1996; Corner, 2002; León, 2010; LaFollette, 2012). A central topic has always been the socio-cultural construction of certainty and authority (Collins, 1987) and its relationship with people's everyday concerns and expectations (Silverstone, 1987, 1994). Historians of science point to the multidimensional traits of the craft (the making of news programs, documentaries, magazines, etc.) in order to understand the nuances of the processes of circulation of scientific knowledge through media, in our case, television (Boon, 2008, 2015).

With this dossier we hope to add a new approach to this scholarship, encapsulated in the motto of the School: "theory meets practice". Our goal was to initiate a fruitful interaction between scholars studying processes of representation and articulation of scientific, medical and technological knowledge on television, and producers of science television programs. How can the practitioners' actual experience of the craft inform historical, sociological and anthropological inquiry? And how may academic research contribute to the representation of "Science on Television"? Trying to answer these questions – we hope – also problematizes disciplinary boundaries and raises new ideas of how to approach "Science on Television" for every professional involved.

In our vision, "theory meets practice" did not end with gathering 45 practitioners, scholars and students in the same room. The "experiment" was meant to go further: We asked the three practitioners to give a talk (after all an academic format despite the numerous video clips shown) and to participate in the ensuing discussion with an audience full of academics. Reciprocally we asked the participants to create a video. Five (groups) of them took up the challenge to do something they had not been taught in their university seminars. Their videos were screened, discussed and evaluated by the practitioners in a specific session of the School.

This experience of changing sides, from practice to theory and from theory to practice was the cornerstone of the School. Practitioners reflected on their work in an entirely new setting, in different terms and in front of an academic audience. Some participants accepted the challenge to communicate scientific content in a TV format and shared these experiences and the problems they had encountered in a final session. In our perception this awakened creativity, enhanced the finding of new narrative strategies and helped to understand the logic of the "other side".

While the School itself ended after three days our goal was to make its contents accessible to a wider audience in order to foster interdisciplinary discussion and ongoing reflection. We wanted to find out whether "theory meets practice" would not only work in a conference setting but also in a written format. Thus we asked all the speakers to write a paper.

"Theory meets practice." This catchy phrase is obviously ambiguous and may be understood in a variety of ways. On the "personal" level it means practitioners meet theoreticians, in our case TV producers get together with academics researching science on TV. Yet on the

"content" level it means to look at practice – how is science on TV "done" – with the tools of theory. In this sense a big leap was required from the practitioners. They were asked to talk about their every-day work in a "theoretical" way. At the same time scholars had to delve deeply into practice and its associated material culture.

It is true though that the focus on "practice", in a deliberately broad sense, is by now well established in the history of science and in the neighbouring disciplines that concern us here (Thompson, 1995; Secord, 2004; Couldry, 2004; Topham, 2009; Bräuchler & Postill, 2010). Scholars ask about how knowledge is actually produced in concrete spaces such as workshops, laboratories and the field. This implies a focus on very concrete materials (objects, instruments), practices (experimenting, observing etc.), actors (motivations, preconceptions, networks etc.) and the general context (social, political and economical). This approach allows to better address questions such as how techno-scientific knowledge is appropriated and how scientific authority is established.

This focus on "practice" does not limit itself to processes of knowledge production but includes by definition also the ways and means by which knowledge is communicated and appropriated. Historians of science predominantly study written sources so the field of "Science on Television" still poses a challenge. This might explain why in the field of science communication and in particular the history of science popularization there is much more scholarship on periodicals, newspapers and books than on "Science on Television". For quite some time now historians of science appreciate how crucial the study of visual culture is. Nevertheless hardly anyone would object to the claim that this "visual turn" leaves much to be desired.

Previous editions of the "European Spring School of History of Science and Popularization" reflected this increasing interest of our discipline in exploring different areas of practices and of material and visual culture. These Schools focused on topics such as museums, journalism, cinema, advertising and propaganda, radioactivity in the public sphere, and visual representations of science.[2] For our edition of the School, in order to capture "Science on Television in Action", we thought it essential to complement the perspective of history of science with approaches from the sociology of science and (in this case: medical) anthropology. The School was structured in three working sessions that attempted to apply as many perspectives as possible (different television formats and their intertextuality, the documentary genre as a reference, and the tension between education and entertainment). "Theory met practice" in each session as each one of them was run jointly by a scholar and a practitioner. The session titles were:

1. From news to fiction: television formats featuring science, medicine and techno-

2. The website of the School: <http://blogs.iec.cat/schct/activitats-2/escola-de-primavera/7th-european-spring-school-on-history-of-science-and-popularization/> include links to the programs of the previous editions.

logy
2. Science documentaries: history and evolution of a genre
3. Science as home entertainment: commercial approaches and their impact on contemporary society

A fruitful and dynamic exchange ensued – through the discussion between these academics and practitioners, but also through the interaction with a critically engaged audience (consisting of graduate students, academics and other practitioners). This dossier is the result of our common endeavour in Minorca. Its structure mirrors the three thematic sessions of the School. In the first section, medical anthropologists Josep Comelles and Serena Brigidi explore the role of fictional television series set in hospitals. In their article "Fictional encounters and real engagements: the representation of medical practice and institutions in medical TV shows" they use anthropological methods and focus on textual analysis. They show that there are a myriad of ways of looking at the intersections between these audio-visual products and the viewers' experiences of medical-health matters. In the end they pose the question in how far medical television dramas contribute to the construction of scientific-medical processes. In "Science story telling in TV documentaries" David Dugan looks back on a long career as film and television director and producer and his own fascination for the life sciences. Finding the proper narrative is crucial to most documentaries, Dugan urges. This is particularly the case if the films deal with science, where the challenge is not only to find the stories to tell, but also the most interesting ways of bringing them to life.

In the second section Tim Boon explains the genesis of "Formal conventions in British science television, 1955-1965". He compares two subgenres of science television ("Sciences" covered more "lab-technology" while "Natural Sciences" stayed closer to traditional natural history topics) and pays specific attention to the media practices involved (use of camera, anchor in studio, etc.). Boon thus asks how scientific authority is created and conveyed in these early documentary television series. Joan Úbeda explores the obstacles documentary producers and filmmakers like himself have to overcome in order to communicate science on television. He maintains that scientific processes are close to impossible to capture on film. Therefore "Creative strategies for scientific TV documentaries" are called for and Úbeda provides us with a practice-proven toolbox of audio-visual storytelling.

Finally, in the third section, Markus Lehmkuhl assesses the "Current state and challenges of science in today's TV: a look at the interplay between supply and demand on European media markets" from a sociological perspective. His paper integrates the production and reception perspectives into a comprehensive picture in order to unlock the basic interplay between supply and demand of science on television. Ana Montserrat draws on her ample experience as a director of a science program on Spanish television. She claims that "Science television is just television" and explains the strategies and rules that are common to televi-

sion genres in general in order to make the program attractive.

The "7th European Spring School on History of Science and Popularization" was a forum where scholars studying the representation and articulation of "Science on Television" and producers of such programs had the opportunity to interact with each other. It quickly became clear that neither are practitioners theory-blind (or unaware of historical dimensions) nor are academics unaware of the concrete conditions (i.e. challenges and limitations) under which science programs are being produced. All the speakers (i.e. all the authors of this dossier) were highly reflective of their own work and the role they are playing in this complex dynamic. In other words: theory and practice did not clash but showed the need to further develop a multi-layered frame of analysis. In the conclusion of this dossier we will not only address systematically the questions raised at the School, but also try to formulate new ones for future research. In this dossier, just like at the School, theory meets practice as well.

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FICTIONAL ENCOUNTERS AND REAL ENGAGEMENTS: THE REPRESENTATION OF MEDICAL PRACTICE AND INSTITUTIONS IN MEDICAL TV SHOWS

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Abstract: *The first episode of* E.R. *(1994-2009) was a revolution and opened a new era in the production of TV medical dramas. Years later,* Grey's Anatomy *(2005-active), among other series, became a cultural phenomenon in the USA. The success of this TV genre is related to its subject matter and some debate has been raised concerning its influence on audiences. In order to discuss the interaction between what is displayed on the screen and the viewers' point of view, we have chosen a few examples of TV medical shows to explore their role in the configuration of the global experience with respect to to specific illnesses. Our hypothesis is that directors and writers expect the viewers to share and embody these representations. Our aim is to map the cultural patterning of this encounter (viewers with TV medical dramas) and shed light on how it engages and constructs the experience of viewers. Through the analysis of some shows produced in the US, the UK and Spain, we conclude that medical dramas cannot be reduced to the condition of entertainment, and that their ethnographic gaze opens up suggestive research perspectives in the sphere of the construction of health, disease and care processes, and of the associated personal and collective experiences.*

Keywords: *TV medical dramas, health and disease representation, audience's experiences, ethnographic gaze.*

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Resum: *El primer episodi de* E.R. *(1994-2009) va ser una revolució i va obrir una nova era en la producció de drames mèdics a la televisió. Anys després,* Grey's Anatomy *(2005-activa), d'entre altres series, esdevingué un fenomen cultural als Estats Units. L'èxit subseqüent d'aquest gènere televisiu està relacionat amb el tema tractat i ha donat lloc a un cert debat sobre la seva influència en les audiències. Per tal d'analitzar la interacció entre allò que es mostra a la pantalla i el punt de vista dels espectadors, hem triat alguns exemples de programes de televisió de temàtica mèdica per explorar el seu rol en la configuració de l'experiència global en relació a malalties específiques. La nostra hipòtesi és que els directors i guinistes esperen que els espectadors comparteixin i internalitzin aquestes representacions. El nostre objectiu és establir el patró cultural d'aquesta trobada (dels espectadors amb els drames mèdics televisius) i dilucidar la forma en què involucra i construieix l'experiència dels espectadors. A través de l'anàlisi de sèries produïdes als Estats Units, el Regne Unit i Espanya, arribem a la conclusió que els drames mèdics no poden ser reduïts a la condició d'entreteniment, i que el seu punt de vista etnogràfic revela perspectives d'investigació en l'esfera de la construcció dels processos de salut, malaltia i cura, i de les experiències associades, personals i col·lectives.*

Paraules clau: *drames mèdics televisius, representació de la salut i la malaltia, experiències dels espectadors, viés etnogràfic.*

TV medical dramas and medical anthropology

The first episode of *E.R.* (1994-2009) was a revolution and opened a new era in the production of TV medical dramas. Conceived as a semi-fictional show, featuring a cinematographic style close to social realism, and shot in a real hospital, it broke most of the narrative conventions of the former medical shows. The subsequent success of this TV genre is owed to its subject matter (Bachtin, 1988; Turow, 1989a; Ostherr, 2013), to its influence on the training of professionals and students (Lait, 1987; O'Connor, 1998; Mikulencak, 1995; Czarny *et al.*, 2008), and on the debates induced in professional ethics (Beca & Salas, 2004; Wicclair, 2008), bioethics (Arawi, 2010) or risks (Belle-Fortune, 2005; Kennedy & Wilson-Genderson, 2011). In France, *E.R.* sparked a national debate on hospital emergency services (Chalvon-Demersay, 1999) and in Spain Milla-Santos (2001) discussed its relation with reality. Other debates are related to their possible influence on people feelings and behaviour (Altman *et al.*, 1997; Radford, 1997), or have drawn attention to the responsibility of production companies and the role of directors and writers (Beca & Salas, 2004; Douglas, 2007; Ostherr, 2013: 190-195), in relation to the viewers' potential embodiment of medical drama content.[2]

The purpose of this article is to analyse, from the perspective of medical anthropology, the representation these TV shows produce of the medical institutional and professional

2. Medical dramas are collective creations: directors, executive producers and scriptwriters play a determining role (Ostherr, 2013: 187-192).

world, and to suggest some issues in relation to the ethnographic value of some of them (Davin, 2003; Espanha, 2002; 2009). Most professional medical anthropologists consider TV shows as entertainment and do not pay attention to them as a source to be explored.[3] Yet, in our experience, our colleagues change quickly their attitude when they take into account the debates within media and TV studies about "realism" (Hallam & Marshment, 2000) and "medical reality" (Ostherr, 2013) and then approach TV medical shows with a professional gaze.

We will also consider their interest in teaching. Weaver & Wilson (2011), suggest that medical dramas have pedagogical values, as potentially significant cultural artifacts, concerning issues related to professional development and identity, negotiations around popular culture, and the perception of the medical worlds they deal with. Our own graduate and postgraduate teaching experience with health professionals and medical anthropologists shows us that, at the beginning, some students are reluctant to accept the value of medical dramas as tools in their training. Later on, however, they come to fully appreciate it.

Our point of departure is to analyse the interaction between what is displayed on the screen – as an effect of specific production processes – and the viewers. We argue that medical dramas contribute to the development of personal experiences and shared feelings related to specific diseases, and in general to our global comprehension of diseases in their social, cultural and institutional contexts. The ethnographic value of the shows is linked to the embodiment of these experiences. In this sense, the ethnographic narratives included in the plots are also crucial to keep the attention of the viewers, for they depict situations that they can identify with. These include viewers' personal or collective experiences regarding specific diseases, medical institutions, and health professionals. In addition, these narratives may even respond in different ways to viewers' needs or quests for information.

In order to carry out our analysis, we have chosen some series produced in the US, the UK and Spain. US shows are easily sold to the world,[4] while British and above all Spanish productions have more limited markets. From the US, we chose two globally broadcasted and very popular shows: *E.R.* (1994-2009, 15 seasons, 331 episodes) and *Grey's Anatomy* (2005-active, 11 seasons, 227 episodes). The first one has become a classic, a cult TV show and a reference to subsequent medical dramas. It has possibly influenced even medical students' and physicians' perceptions and beliefs (O'Connor, 1998). On the other hand, the interest in *Grey's Anatomy* is due to its huge success among the general public, including medical students, and even in relation to government-funded programs of health education

3. On the research and teaching value of medical films, documentaries and TV shows see: Ostherr, 2013; Turow, 1989; Turow, 2010; and Kirby, 2011. In medical anthropology research, it is quite impossible to find cross-references to media productions, even in classical discussions about art, literature and ethnography (Clifford & Marcus, 1986; Geertz, 1985, 1998).

4. Sometimes, American producers develop remakes of European productions: for instance, *Red Band Society* (2014) is a remake of the Catalan TV3 production *Polseres vermelles* (2011-active).

for patients (Brian, 2009). It has been described as "television's hottest show" (*New York Times*), which situates it far from the documentary profile of *E.R.* At any rate, *Grey's Anatomy* has become a cultural phenomenon in the US and abroad, enjoying high ratings since its debut.[5]

Our third example is a BBC production: *Bodies* (2004-2006, two seasons, 17 episodes). British critics have said it was "the greatest television drama of all-time".[6] It is comparable to *E.R.* in ethnographic terms, the quality of storytelling, and the depicted medical cases. Our interest was to look at the critical gaze at the hospitals of the British National Health Service as produced by a public television. In this sense, it may not be representative of popular British TV shows, such as the medical soap opera *Casualty* (1986-active, 29 seasons, more than 600 episodes), yet we chose it because of its potential ethnographic value.

Finally, our forth example is *Hospital Central* (2000-2012, 20 seasons, near 300 episodes), broadcast by the private Spanish Channel Tele 5, owned, in turn, by the Italian group Mediaset (Bustamante, 2013). This show is the heir of two other medical shows, *Farmacia de Guardia* (1991-1995) and *Médico de Familia* (1995-1999) that were comedies about the fun and friendly everyday life (*costumbrismo*) in an urban pharmacy and in the family of a handsome general practitioner, respectively. *Hospital Central* is an example of the same Spanish *costumbrismo*, yet this time in a hospital (Benet Ferrando, 2012). It features a combination of comedy and drama in a hospital setting, although it can also be placed in the tradition of international medical dramas set in hospitals, such as *Dr. Kildare* (1961-1966). Despite a certain absence of originality, it had record audience ratings (up to 35.3% share) in Spain.

The different medical settings depicted in these programs and their varied social and cultural contexts allow for a greater contrast between the cases studied. With this in mind, our hypothesis is that directors and writers expect the viewers to share and embody these representations. Thus, our aim is to map the cultural patterning of this encounter (viewers with TV medical dramas) and shed light on how it engages and constructs the experience of viewers – the *health care systems* in Kleinman's (1980) words.

Medical dramas, medical anthropology and health promotion

Medical dramas have value for medical anthropology.[7] Most of them, in a realistic or naturalistic regard, depict the medical world and its changes from 1960. Their cinematography is today an ethnographic source in spite of their fictional dimensions because they show

5. Lacob, Jace (November 3, 2010). "*Gray's Anatomy*'s 7th Year Surge". *The Daily Beast*. The Newsweek Daily Beast Company.
<http://www.thedailybeast.com/articles/2010/11/03/greys-anatomy-private-practice-shonda-rhimes-speaks-out.html>.

6. <http://www.theguardian.com/tv-and-radio/tvandradioblog/2010/jan/12/guardian-50-television-dramas>.

7. On medical anthropology see Comelles & Martínez Hernáez (1993) and Martínez Hernáez (2008).

cultural diversity and participates on the construction of viewers' experience on disease, illness and sickness and of medical and health related knowledge (Boon, 2008; Kirby, 2011; Kirby, 2013; Ostherr, 2013).

Audience interest in these series lies in their ethnographic value and the viewers' capacity to recognize themselves and the medical settings from their own specific individual or collective experiences (Kirby, 2014). Unlike thrillers, sci-fi, or action shows where implausibility is admissible, health sector representations – whether medical dramas or other genres – *must be realistic* to avoid misinterpretations or false ideas about the medical institutional or professional practice (Collee, 1999).

Up until the 1990s, the show's producers in USA accepted medical supervisors from the American Medical Association and took pains over the realism of scenes in natural settings (Turow, 1989b). Nowadays, the health authorities in all countries monitor content to avoid inciting dangerous beliefs or practices that do not comply with scientific criteria (Turow & Gans, 2002), or suggest the screen writers to produce dialogues promoting healthy practices, such as dieting, non-smoking or abstaining from drinking, among many others.[8] Despite concerns that these series could affect health practices, researchers found that breast cancer storylines in *E.R.* or *Grey's Anatomy* had little impact on women (Hether *et al.*, 2008). Other scholars have explored their impact on health promotion (Howe *et al.*, 2002; Weber & Silk, 2007), in specific problems such as survival chances (Van den Bulck, 2002), or try to answer the question of whether medical dramas can help saving lives (Eisenman *et al.*, 2005). Furthermore, Western society finds itself in an extremely medicalized period. This means that medical dramas permit viewers to feel medically controlled and, at the same time, they can keep control over their health and their family. With the disappearance of corporate interferences, which could be interpreted as censorship (Turow, 1989a), the ethnographic dimension of medical dramas took a qualitative leap following the debut – and huge success – of *E.R.* This was also due to the change from 16mm film format to video, which offers an infinite room for manoeuvre and hugely reduces costs.

The combination of these two factors had an immediate effect. Collee (1999) in a *British Medical Journal* editorial reflected this in his comparison of the moral and scientific clarity of *Doctor Kildare* (1961-1966) with the deliberate expression of the complexity of the actual health care sector in *E.R.*, and the representation of the London Hospital in *Casualty 1900* (2006-2009), set at the beginning of the twentieth century,[9] whose naturalism and greater depth demand higher levels of concentration from the viewer, but also lead to greater demand for quality.

8. This also happens in many "non-medical" TV shows and soap operas.

9. *Casualty* (2006-2009) is a 10 episodes show: *Casualty 1906*, three episodes of *Casualty 1907*, and six of *Casualty 1909*, six episodes. Recently three shows are historical careful reconstructions: *Call the Midwife* (2012-active), *The Knick* (2014-active) and a part of the storyline in *Deadwood* (2004-2006).

E.R. was the first medical drama to be included in the new show languages in television, before *The Sopranos* (1999-2007) and *The Wire* (2002-2008) (Casas, 2010). But moreover, its narrative breakdown show the dismantling of the boundaries between reality and fiction to create a distinct reality contained in the manufactured product: the "reality effect" (Glevarec, 2010). However, medical dramas, unlike the "reality shows" featuring all manner of ill people and oddballs, maintain a rigor – already present in medical documentaries (Boon, 2008; Ostherr, 2013) – that we will discuss below. And while the "reality effect" is now present in some of the best high quality series, it can equally be applied to written ethnography and ethnographic film.[10]

We consider the ethnographic dimensions of medical dramas crucial to keeping viewers' attention, by depicting situations that they can identify with from their personal or collective experience of doctors, nurses or hospitals, or by providing responses to their own needs or quests for information (Ostherr, 2013). A chronological review reflects the evolution of health services and professions (Hallam, 2012), and the representations and narratives on illness in the last fifty years.[11] *House M.D.* (2004-2012) is somewhat different because it focuses much more on depicting diagnostic reasoning and goes beyond the realist or naturalist register.[12] Cases, diagnostic debates, and deliberations over treatments are dealt with in the episodes, and viewers witness the controversies and ethical dilemmas present in global culture.[13] In addition, the universality of medical dramas distinguishes them from thrillers like *24* (2001-2010), sci-fi dramas like *Farscape* (1999-2003), fantasy genres like *Supernatural* (2005-active), or even realist and naturalist comedies or dramas like the American *Desperate Housewives* (2005-2012) or the Spanish *Cuéntame cómo pasó* (2001-active). *E.R.* shows a US hospital in naturalistic terms, far from the Spanish show *Hospital Central*, or the British NHS hospital culture represented in *Bodies* (2004-2006). Also removed from hospital everyday practices, *Everwood* (2002-2006) shows a collateral gaze on a general practitioner in the rural countryside, in a plot based on a father-son relationship. The teenager son's world in this show serves to present

10. The ethnographic value is explicit in shows like *Southland* (2009-2013), a thriller conceived as a docudrama about the day-to-day events in police patrols, or in *Treme* (2010-2014), a semi-fictional ethnography about New Orleans after the Katrina hurricane.

11. Some refer to the technical reliability of the representation; see the study of cardiopulmonary resuscitation in British series during the 1980s and 1990s (Gordon *et al*., 1998).

12. The evolution of the ideal type of doctor over the last fifty years can be followed by comparing the hospital doctors depicted in *Dr. Kildare, Ben Casey, E.R., House M.D.* and up to the interns in *Grey's Anatomy*. Also general practitioners have evolved from urban *Marcus Welby* (1969-1976), to the rural GPs in *Everwood* and *Northern Exposure* (1990-1995) or the present urban *Private practice* (2007-2013). About the evolution of ideal types of physicians, see also Comelles (2007).

13. Davin (2003) has compared viewers' perceptions of series, soap operas and documentaries.

highly nuanced global ethical dilemmas heightened by the highly conservative cultural rural context in which the action is set.[14]

Medical dramas intervene also in the cultural production of *ideal types* of professionals (Comelles, 2007a, 2007b; Strauman & Goodier, 2011; Hallam, 2012), institutions and the way they organize space and rituals (Lepofsky *et al.*, 2006). They represent the hegemonic conception of health, illness and care,[15] sometimes in a very critical way. Nevertheless, there are changes. The characteristic handsome male doctor characters have shifted to depict complex care teams with large gender and ethnic diversity (Ye & Ward, 2010), as well as more horizontal team relationships. The representation of nurses has moved away from their habitual supporting roles.[16] Carol Hathaway, a nurse, had a leading role in *E.R.*, where she showed her authority over the doctors. This pattern was recently followed by *Nurse Jackie* (2009-active). In *Grey's Anatomy*, Nurse Debbie takes revenge on a female doctor for her lack of respect toward the nurses by only passing on calls for basic care. Gender relationships are no longer limited to sex or love, but involve the sharing of tasks. Women are given an increasing number of leading roles. In *The night shift* (2014-active), Dr. Jordan Alexander holds the position of head of the emergency room at night; Dr. Jenny Bremner is a talented cardiothoracic surgeon in *Monroe* (2011-2012); also, Dr. Cristina Yang in *Grey's Anatomy*, Nurse Jackie in her namesake series, or Veronica Flanagan in *Mercy* (2009-2010), hold leading roles. Therefore, women's roles have become more intriguing and complex owing to the professional skills of their characters, as opposed to being just associated to illnesses, such as with Dr. Izzie Stevens' brain cancer in *Grey's Anatomy*, or Dr. Catherine Black's mental illness in *The black box* (2014), or beauty and love affairs, such as with Drs. Meredith Grey and Callie Torres in *Grey's Anatomy*. The shows deal with cultural and social diversity through topics like immigration, body modifications, voluntary amputations (Hurtado, 2015), intersexuality (Gregori, 2015) and bioethics. Less favourable images of physicians emerge that apparently influence doctor-patient relationships (Stinson & Heischmidt, 2012). In contrast, medical pluralism tends to be treated with indifference; perhaps because it goes beyond the established limits.[17]

14. European medical dramas tend to distance themselves from the North American ones, by describing idiosyncratic profiles of medicalization in different cultural settings (Espanha, 2002), or linking specific topics with local cultural contexts (Strauss & Marzo-Ortega, 2002).

15. See Reagan, L J.; Tomes, N; Treichler (2007), the second edition of Turow (2010), and Dans (2000).

16. On the ethnographic value of the series to nursing, see Mikulencak (1995).

17. Some alternative medical practices appear collaterally in *Private practice, Grey's Anatomy, Everwood,* and *Northern Exposure.*

North American, British and Spanish shows

The relationships between the globalization of medical dramas and their idiosyncratic cultural dimensions can be illustrated comparing the first three episodes of the opening seasons of the American *E.R* and *Grey's Anatomy*, the Spanish *Hospital Central,* and the British *Bodies*, all of which are set in hospitals, the first three in Emergency Service Departments and the last one in an Obstetrics and Gynaecology unit that also deals with emergencies. The authors of *E.R.* and *Bodies* had medical training. The scripts and characters of *Hospital Central* were based on *E.R.*'s. Both *Bodies* and *E.R.* were filmed on location whereas sets were used for the other two.

E.R. sets out to document the emergency service of a North American public hospital in Chicago and the extreme working conditions faced there. The areas within the emergency service – waiting rooms, doctors' working and rest areas, and the patients' cubicles – are described through a naturalist lens. There are no external shots and the overall impression is claustrophobic. Common sense forms the basis for the depiction of the relationships between doctors, health professionals and patients, and the attention paid to distinguishing professional jargon from dealings with patients and relatives is particularly effective. In general, doctors – including a then unknown George Clooney – and other health workers are portrayed as normal people; none of them are saints, and as doctors or nurses, they have to accept the impact of their work on their families, personal or economic choices, and an arduous pace of work for comparatively low financial reward. There are constant references to the organization of the service, how it works on a daily basis and the socialization and learning processes of new members. Staffs are portrayed as a team, with a balance of roles that breaks the stereotypical patterns of previous series. The nurses are of a different generation, they dress and wear their hair like the nurses we are familiar with, and in the first episode, when the doctors ask them to bring some coffee, they tell them to get it themselves. The nursing staffs have a vital role in numerous processes of mediation with the patients and their families. There are frequent comments on the problem of financing hospital stays, even at the admissions stage, and the nurses have a certain sympathy for the patients' circumstances, the problems of attending patients in the waiting rooms, and good interpretations are sometimes given on the social and cultural epidemiology[18] of the cases they take care.

The private Spanish channel Tele5 broadcasted twenty seasons of *Hospital Central*. Filmed on set, and despite a good production design, the spaces are much emptier. Set details are limited, and for the common viewer, *Hospital Central* evokes a Spanish private hospital and not a public one. The producers hid any kind of specific public hospital symbols. Paradoxically, the emergency service in E.R. is closer to those in European public hospitals than the one depicted in Hospital Central. Although the storyline of the first episode of *Hospital Central* covers the effects of a multiple accident, its depiction is less delib-

18. About this concept see Haro (2011).

erately chaotic than in *E.R.* in an attempt to create a positive impression of the crisis management model and the work and responsibility of the professionals involved. The hospital staffs operate on more hierarchical lines than in *E.R.* and the nurses reflect the classic stereotypes: attractive, young, and subordinate women (with some exceptions). This is the only one of the four series in which nurses and patients touch and joke with each other not only when they are carrying out their professional duties, a common practice in Spanish health institutions. However, the effect of two levels of censorship is patent in *Hospital Central*, one seen in the respect for the ideal type of doctor imposed by the corporate overseers, and the second evident in the absence of a naturalist register that would likely have attracted political pressure if the situation of public hospitals had been dealt with critically as it was in the BBC's *Bodies*. Tele5 and Spain are not the BBC and the United Kingdom, and it shows. Although the hospital's public or private status is deliberately ambiguous, some of the relational anecdotes evidence cultural traits typical of the Spanish Social Security System, and economic references do not concern the patients' individual insurance cover, but the availability of resources in the institution. *Hospital Central* falls strictly within the hegemonic medical model. Common sense disappears; they do not "come down to earth" and the doctors' discourses "are doctors' discourses", whereas the spontaneity of the patients ties in with the Spanish cultural and theatrical tradition of the "funny guy" that has no equivalent in the other series.

Bodies is based on a book that severely criticized the British National Health Service. A limited number of predefined episodes were commissioned with a conclusion that did not anticipate any new seasons. This is common practice in British series, like with *Casualty 1900* or *Call the Midwife*, which tend to have more carefully prepared scripts and more sophisticated, less functional cinematography than the North American or Spanish series. *Bodies* was shot in a public hospital with documentary and ethnographic intentions. Scrupulous attention is paid to the narratives of space and of the social, personal and professional relationships; professional and class roles are clearly defined to show not only the day-to-day running of the unit, but also the effects of the organizational models and class conflicts on the patients' health, as well as the corporate silence surrounding medical errors. The fact that *Bodies* was condensed into a limited number of episodes might give the impression of exaggerated conflict that may be more diffuse in reality. However, the ethnographic intention lies in highlighting the roles and conflicts between the doctors, nursing staff and administration in a university hospital that obtains funding from its research activities, and needs results in order to receive basic funding within the public managed care system. The scripts include medical errors as well as successes, power games in order to obtain academic promotion or research funding, administrative interference in the diagnostic and treatment decision-making process and, as in *E.R.,* all the characters in *Bodies* are portrayed as ordinary people in a rigorous endeavour to achieve ethnographic naturalism. With a less choral structure than the others, the series gives an impeccable depiction of scenes from

everyday clinical practice. The ethnography describes reasonably well the public sector management models, and the European professional training structure.

Grey's Anatomy is very different. It was created after the success of *House M.D.* in 2004. The storyline is based on the face-to-face relationships between a cluster of young doctors and nurses, including their sexual approaches and relationships. Its set production design is closer to *Hospital Central* than to the other two series. Here, the storylines centre on the personal and private relationships of the characters against the background of a highly competitive surgical unit and based on a conception firmly rooted in surgery. Although medical practices are accurately depicted, such as in *Hospital Central,* the storyline stays close to the teen high school show format and the plot include a lot of personal sentimental and sex relationships between doctors and nurses.

The foremost feature the four series have in common is probably the way medical practice is dealt with, more naturalistic in *E.R.* and *Bodies*, more stylized and ritualized in the other two. *E.R.* and *Bodies* both have a clear documentary intention but from two distinct ethnographic perspectives: *E.R.* may be associated with *clinically applied anthropology*, a perspective that aims to reveal rather than judge, whereas *Bodies* comes closer to a *critically applied anthropology* approach by focusing more on the economic-political context.[19] Both share an ethnographic value that may be used in training for health professionals and medical anthropologists. The two follow different strategies: *E.R.* tells the story and leaves its interpretation to the viewer, who has to deduce the economic-political context; *Bodies* spells it out. Both aim to entertain, but also to raise the viewer's awareness, although with a significant cultural bias that differentiates the United States from the United Kingdom.

Hospital Central and *Grey's Anatomy* do not have a specific ethnographic intention, but rather use the health sector as the setting for a melodramatic storyline, without attempting to engage the viewer and thereby raise civil consciousness, though its plot lines do contain cases that allow for this. The differences between the two lie in the distinct profiles of North American screen comedy and its Spanish equivalent, based on a long tradition of theatre in particular, as well as popular cinema. *Grey's Anatomy* continues in the mark of popular comedy for teenagers or young audiences; *Hospital Central* follows the conventions of *comedia madrileña*, a genre based on tradition and habits present in Spanish cinema since the times of Franco's regime, and rooted in previous theatrical conventions, infused with influences from popular Italian right-wing comedy cinema. Nonetheless, both present some marginal ethnographic features and interesting cases.

Medical dramas and the health, disease and care processes

Having established their ethnographic value, which is also present in medical dramas featuring general practitioners – particularly *Everwood* and *Northern Exposure* – we now turn

19. For both concepts see Comelles & Martínez-Hernáez (1993).

to explore their role in the cultural construction the viewers make of the health, disease and care processes. The crucial point is the decision about what disease processes are shown. This explains why most of the cases are linked to highly controversial diseases, such as cancer, degenerative diseases, or the consequences of accidents and injuries. In most of them, ethical dilemmas are present, such as euthanasia or aggressive interventions, plots referring to debates about abortion or the conceptions of health and disease of teenagers, or the legal implications of some therapeutic decisions, as in *Everwood*. Institutions concerned with health promotion closely watch medical dramas because they can either fuel good practices by one side, or broaden the public debate.

In *Doctor Kildare*'s times, the representation of medical professionals was always positive. The current trend is to go to a more naturalistic representation, showing the complexity of actual medical practice well balanced in terms of gender and sensible to the problems derived from the management of diversity. In the first episode of the first season of *E.R.* (1994), the cinematography of the disclosure of a cancer in a dialogue between a young female doctor and a male adult patient is a brilliant exercise of verbal and non-verbal communication between two different people who are speaking different languages. *Bodies*, from a more critical perspective, does not avoid the political and social concerns related to the management of female cancer cases. The ability of directors and screenwriters to develop cinematography very close to an ethnographic gaze gives an extra value to medical dramas.

Medical anthropology has demonstrated how these processes are universally constructed in society on the basis of everyday experiences, in face-to-face relations among lay people, folk healers, and professionals either within or outside institutions (Menéndez, 2005). Medical dramas represent these processes that result in characters acquiring experience and therefore offer a reflection on the reality we all share. What role do they play when we watch them on the television screen, with the light on, in the company of our families? We consider that ethnography, as a tool to represent reality, has always been able to evoke in the reader – or in this case the viewer – human dramas regardless of cultural differences. Ethnography is a marvellous tool that transports life from one place to another and *translates* it (Geertz, 1985); and this includes the ethnographic dimension of medical dramas, however dreadful they might be. For decades, family or neighbourhood audiences congregated around a single screen, as in the case of the Spanish *teleclubs* in the 1960s, for example.[20] This practice gradually disappeared with the spread of television sets into private homes and has become more demographically segmented.[21] The collective experience was condi-

20. Collective television viewing has made a comeback in bars and pubs for football matches and other sporting events. This space remains alive in series production: shows like the medical drama Everwood, described as a *family show*, are aired during family time slots in order to attract the widest possible audiences as they contain three generational story arcs: adolescents, parents and grandparents.

21. Even in the US, where NBC, CBS and ABC cornered audiences by syndicating local TV stations.

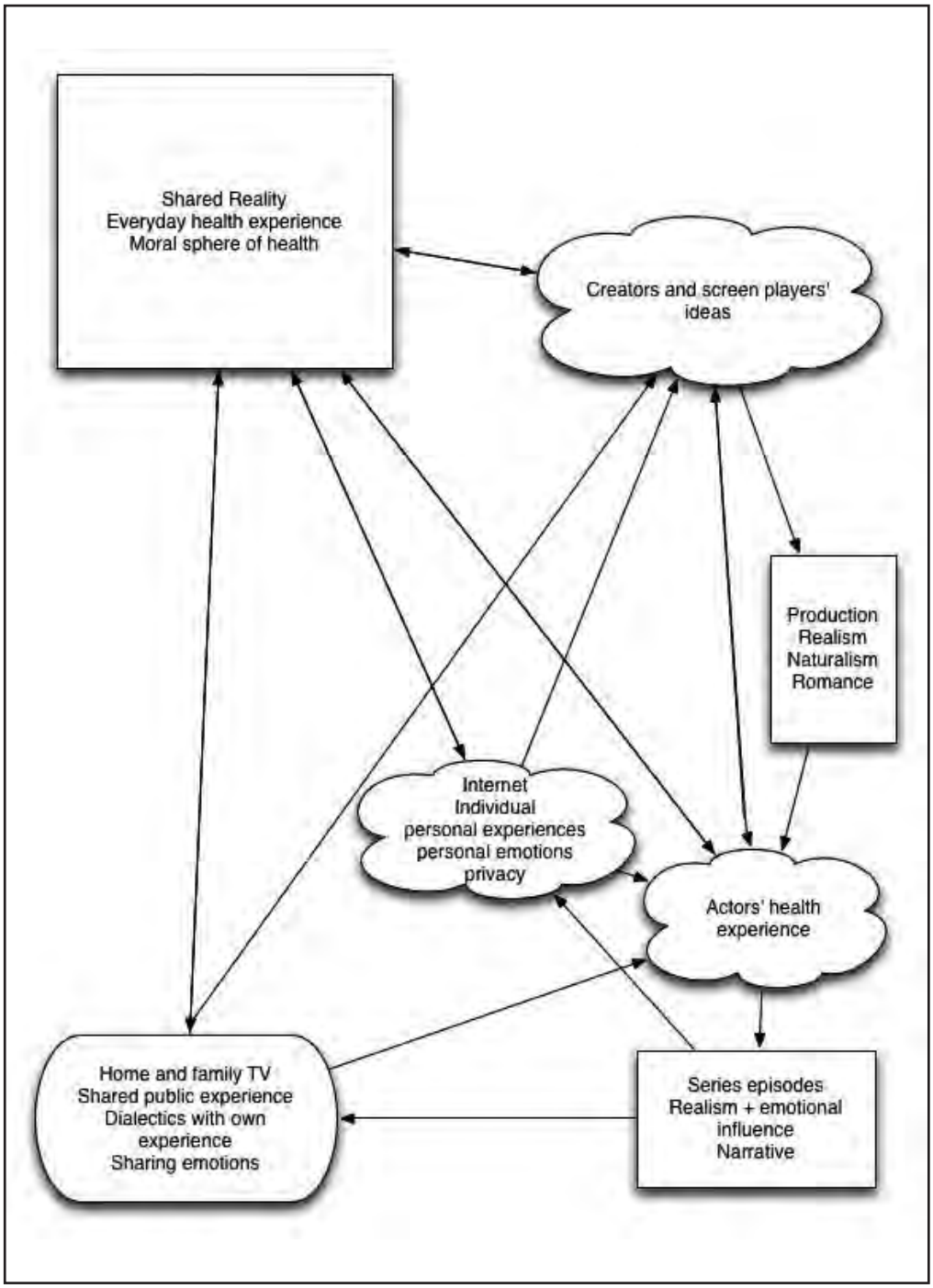
tioned by broadcasting schedules and a limited number of channels. The narratives of *Doctor Kildare, Ben Casey* or *Marcus Welby* moved within the coordinates of good realist cinema with an educational inclination, able to control emotions but not evade problems and conflicts, in productions suitable for any age, and used as a tool for disseminating the virtues of hegemonic medicine.

This has all changed. Globalization has spearheaded the atomization of the audio-visual market into compartments specialized by genre, culture, religion, class or demographic segments. The torrid episodes of sex in *Grey's Anatomy, Nip/Tuck* (2003-2010) or *Nurse Jackie* are made possible by viewing on demand, regardless of schedules, on laptops, smartphones or iPads.[22] There is a greater moral permissiveness *represented* –that would be the simple explanation –, but this is necessary in order to bring them closer to reality shows where the limits between reality and fiction are blurred. The experience of watching on one's own leaves no room for discussion or comment with one's peers, except on the virtual networks, where illusionary fabrication predominates; it is merely an individual experience. And this raises some pertinent questions regarding the construction of the health, disease and care process. The aim is to present a network of relationships based on the idea that viewers, producers, directors, writers, actors and others involved in the productions share their own experience with health, illness and care when they write the screenplays, film them, act in them or watch them. The dialectics between them work on different levels: writing, filming, acting, viewing, and sharing the experiences with their own networks introduce a major change in the hegemonic production of health, illness and care experiences. For centuries these experiences were the fruit of face-to-face relationships between social actors and professionals; now the production of visual representations of ethnographic value comes to life at home.[23]

The interactions among social actors, from creators and screenwriters to actors and viewers, constitute a complex space with different levels of visual interpretation. The magnitude of the casts in the choral series seeks to widen the spectrum of communication with viewers since only the wide-scale diffusion of medical dramas on the most generalist channels guarantees their medium- and long-term economic viability. We try to depict the complexity of the process in the following chart (figure 1):

22. Cinema based in movie houses did not have the everyday feel or the ubiquity that television would have, and much less the hegemonic role that television played between 1950-1960 and the end of the century. Internet did not start broadcasting video on a mass scale until 2005-2007. On video formats see Cuadra-Colmenares & López-Yebes (2008).

23. Clifford Geertz (1985) explained in this way the meaning of written ethnographies.


Shared Reality
Everyday health experience
Moral sphere of health
Creators and screen players' ideas
Production
Realism
Naturalism
Romance
Internet
Individual
personal experiences
personal emotions
privacy
Actors' health experience
Home and family TV
Shared public experience
Dialectics with own experience
Sharing emotions
Series episodes
Realism + emotional influence
Narrative

Conclusions

This article attempts to show two things. Firstly, medical dramas cannot, and indeed must not be reduced to the condition of entertainment, even when the portrayal of the health, disease and care process is insufficiently rigorous. The porous boundaries between fiction and reality call for prudence in this respect. Less than rigorous content with simplistic language can have a much greater impact than more sophisticated narratives that almost fall into the documentary format.

Secondly, ethnography in medical dramas opens up suggestive research perspectives concerning the construction of the health, disease and care process, as well as in the construction of the personal and collective experience particularly in relation to some diseases widely represented in the plots. Whereas it is not easy for an individual to become Jack Bauer (*24*), Admiral Adama (*Battlestar Galactica,* 2004-2009*)*, or Detective McNulty (*The Wire*), all of us who watch medical dramas encounter a reality that could be our own: we recognize Gregory House or Nurse Jackie in the hospitals we visit. We recognize the discussions involved in reaching a decision, or we identify with the on-screen suffering that at some point in our lives we have also experienced. Moreover, we find answers regarding the excessive bureaucratization of the medical system, cases of medical incongruity, or the need to improve communication processes. Medical dramas may help to enhance patient's empowerment, even give clues to teach how to became a good patient in the terms Allué (2013) suggests. Paul Valéry spoke of cinema as *divertissement pour ilotes*. We refer to the television as the idiot box. But the box has matured to become a mirror with which we converse day in, day out, a kind of invisible friend that accompanies our solitude and watches out for our discomforts.

TV Shows quoted

24 (2001-2010), USA
Battlestar Galactica (2004-2009), USA
Ben Casey (1961-1966), USA
Black Box (2014), USA
Bodies (2004-2006), UK
Call the Midwife (2012-active), UK
Casualty 1900 (2006-2009), UK
Cuéntame cómo pasó (2001-active), Spain
Deadwood (2004-2006), USA
Desperate Housewives (2005-2012), USA
Doctor Kildare (1961-1966), USA
E.R. (1994-2009), USA
Farscape (1999-2003), Australia
Grey's Anatomy (2005-2014), USA

Hospital Central (2000-2012), Spain
House M.D. (2004-2012), USA
Marcus Welby (1969-1976), USA
Northern Exposure (1990-1995), USA
Nurse Jackie (2009- active), USA
Nip/Tuck (2003-2010), USA
Polseres vermelles (2011-active), Spain
Private practice (2007-2013), USA
Red Band Society (2014), USA
Southland (2009-2013), USA
Supernatural (2005-active) USA
The Knick (2014), USA
The Night Shift (2014), USA
The Sopranos (1999-2007), USA
The Wire (2002-2008), USA
Treme (2010-2014), USA

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SCIENCE STORY TELLING IN TV DOCUMENTARIES

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Abstract: *The three letters, DNA, have taken on a new meaning and significance over the past 60 years – not just in biology – but in everyday life. This paper analyzes a number of different approaches to unraveling stories about life sciences on television. Some are playful, some feature conflict, some pose riddles, some tackle big questions and some feature unusual timelines; but they all follow a strong narrative. Drawing on clips from films I have directed or produced that feature DNA as a theme, I will illustrate a variety of techniques (visual and structural) to television story telling. Finding the right narrative is critical to most documentaries, yet even more for films about science, because scientific topics can become dry and devoid of emotional engagement. There is no shortage of enthralling science stories to tell. The challenge is to find interesting ways to bringing them to life.*

Keywords: *science, television, popularization, documentary films, story-telling strategies*

Resum: *Les tres lletres que formen la paraula ADN han experimentat un canvi en el seu significat en els darrers seixanta anys, no només en biologia, sinó en la vida quotidiana. Aquest article analitza un conjunt de diferents estratègies per explicar històries sobre ciències de la vida a la televisió. Aquestes poden ser entretingudes, introduir conflictes, plantejar enigmes, abordar grans qüestions, o mostrar línies temporals inusuals; però totes segueixen una narrativa robusta. A partir de clips de pel·lícules que he dirigit o produït, il·lustro una varietat de tècniques (visuals i estructurals) per*

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explicar històries a la televisió. Trobar la narrativa adequada és clau en la majoria de documentals, i encara més en aquells que tracten sobre ciència, ja que els temes científics poden esdevenir àrids i mancats de lligams emocionals. Les històries sobre ciència apassionants no són escasses. El repte és trobar-les i trobar també formes interessants de donar-hi vida.

Paraules clau: *ciència, televisió, divulgació, documentals, estratègies narratives*

Introduction

The three letters, DNA, have taken on a new meaning and significance over the past 60 years. Across the fields of biology, medicine and forensic science the impact of this double stranded molecule with its simple, but life defining, four-letter code has been profound. Yet DNA has now entered the language and has come to mean something much broader. When we say something is in that company's DNA or that brand's DNA, we are referring to the fundamental and distinctive qualities that define that organization or object. Progress in the development of DNA science over the past six decades has been so rapid and extensive that the general public has an increasingly vague concept of what is at stake. This research has far-reaching social, economic, political and even cultural consequences; so there is a real need to communicate the science in an engaging way.

This paper describes and analyzes a number of ways of tackling stories about science in television documentaries. Some of these approaches are playful, some feature conflict, some pose riddles, and some tackle big questions. Drawing from clips of films I have made that focus on DNA-associated knowledge and technologies, I will try to illustrate a variety of strategies to science story telling on television. All these approaches, despite being very different, are aimed at creating and maintaining a strong narrative. Of course, finding the right narrative is a critical factor in most film and television story telling; however it is especially important for films about science, where the subject matter can seem dry, distant and devoid of emotional engagement. Building a strong narrative is a vital driver in producing inspirational and engaging films about science.

What follows is a distillation of the lecture I gave on May 16th, 2013 at the "7th European Spring School of History of Science and Popularization: Science on Television". The School (which took place in Maó, in Minorca, Spain) offered a rare opportunity to establish a fruitful and dynamic exchange between academic theorists, in this case historians of science focusing on science popularization issues, and media practitioners, who produce and direct television content.

The main motto of the School was "when theory meets practice". Theorists and practitioners rarely come together to discuss the media and its exploits. Both are wary of crossing the apparent gulf that exists between the two. It would seem that the production of films and television programs has somehow to be achieved without the meddling of academic

analysts because of their lack of experience in the actual craft. Correspondingly, it would seem that the media (in this case, film and television) practitioners have no say or interest in the analysis of their own work, because they are too preoccupied by the pressures of their trade to spend time reflecting on any deeper influences or consequences of their productions.

However, the School showed the unequivocal advantages of bringing together these two professional clusters. It proved to be an enriching experience, not only through the interaction between the academics and practitioners participating as professors, but also through the exchange with a critically engaged audience of students (among whom there were more academics and practitioners). Indeed, both groups showed that they could very well inform each other on many aspects of their respective professions.

Concerning narrative around science on television

With this in mind we are going to focus here on technical questions that are commonplace in the making of films, particularly documentaries, and above all with those having science content. In particular we will focus on the problem of finding the right narrative when dealing with scientific subject matter. But what do we mean by the *right* narrative? I will draw on my own experience in making films, particularly around DNA science and technology, to illustrate the many challenges to be confronted.

Producers attempting to convey scientific (or any kind of) knowledge to a mass audience have wrestled with a number of different techniques. Most practitioners try to fulfill the century-old dictum on the need to ***educate, inform and entertain*** (this dates back to a statement made in 1922 by David Sarnoff, then head of the Radio Corporation of America, RCA; but it was soon also adopted by John Reith, then General Manager of the BBC).[2] This well-known diktat seems to place *entertainment* in third place, which suggests how the priorities of mass audiovisual media were perceived in its early stages of development. Nevertheless, practical experience of trying to reach an audience in an industrial, market-driven society soon made it clear that there was a need to entertain in order for the medium to achieve the other goals. Much has been said about how entertainment can be achieved when the subject matter is complex scientific, medical or technological information. Scientists vary enormously in their reaction to this process. Some are determined to explain every nuance and qualification of their research and feel affronted if there is too much over-simplification. Some despair at misconceptions and misinterpretations of data. Others are grateful that there is interest in their research at all and go out of their way to help. They understand the need to engage the public in an entertaining, informative way.

It is easy to appreciate how science can be misrepresented in popular media. Sometimes when there are disagreements between scientists, the controversies are glossed over to sim-

2. <http://www.bbc.co.uk/historyofthebbc/resources/in-depth/reith_5.shtml>

plify the message. At other times the sparks of controversy are fanned into an inferno that generates more heat than light. But increasingly an understanding has been reached that science is not an activity that can be conducted in private solely for publication and discussion in academic journals. To obtain funding, appreciation and sympathy for science, scientists realize they need to engage the public through mass media. In many institutions this is now part of their job description. So things have moved on since the days when scientists complained about the trivialization of science. Nowadays, they are much more likely to appreciate the need to get across key messages and their chief concern is the lack of science coverage on television.

Today scientists sometimes collaborate closely with science filmmakers to help tease out the most imaginative and dramatic way of presenting their science. For instance, on our recent *Your Inner Fish* series (2014, see below), we were in constant dialogue with scientists throughout pre-production and post-production to ensure the accurate portrayal of their work. When we depicted fossils and extinct animals in CGI sequences, scientists checked to make sure they were accurate in every anatomical detail. Scripts were discussed at length with Neil Shubin[3] and a team of scientific advisors at various stages of production, right through to the final recording of the narration. Increasingly, this spirit of collaboration and inclusion in the film making process is built into the production of major science documentaries. Obviously on more fast-turnaround shows and TV news stories there are different pressures and no time for such a dialogue. But overall, scientists tend to be more sympathetic to the challenges faced by the filmmaker than they used to be, even if pressures on their own time mean they cannot always offer extensive help.

Looking at how science can be turned into a strong, successful narrative, there are few better places to begin than with Jim Watson's account of the discovery of DNA in his best-selling book *The Double Helix* (1968). This is deservedly seen as a classic of science story telling. Leaving aside its historiographical limitations, Watson demonstrated that a potentially dull scientific piece of information (the analysis and interpretation of X-ray crystallographic data) could be turned into a human story infused with competition, jealousy, espionage and drama. It is in the end a very personal narrative – an account of DNA's central part in his life – that reflects his mischievous persona. His strongly flavored opinions about his colleagues and his indiscreet comments about their motivation and success shocked many scientists when it was first published. But it is that personal, undiluted honesty that makes it such an engrossing tale (Watson originally wanted to call the book *Honest Jim*).

To attract a broad audience to scientific endeavors, it is more engaging if you can bring a personal lens to the story. By doing this, the narrative unfolds against a background of shared human experience and emotional force that is common to most human activities beyond the confines of the lab. This is not to say that the science should be ignored, rather

3. <http://pondside.uchicago.edu/oba/faculty/shubin_n.html>

that the audience is more likely to be motivated to take an interest in a subject that we can see has captured the imagination of a researcher. There is a common misconception that the only way to reach a mass audience is to 'dumb down' and trivialize the science. TV shows that do this underestimate the intelligence of the audience. My philosophy is that you can get across a lot of interesting scientific information once you have engaged the audience in the characters at the heart of the story. Even in this paper I will thread elements of my own personal story to add a secondary narrative thread that sets the ideas into a chronological context.

By some serendipitous means, DNA has always played a big part in my life. To begin with, I was born the same year and month that Watson and Crick celebrated the discovery of DNA's double helix structure (Watson & Crick, 1953). Later on, at college, I read Watson's classic textbook *Molecular Biology of the Gene* (1965), and was completely enthralled by its clarity and brilliance. And gradually my early fascination with the twin threads that define DNA's structure was carried over into my professional work as a film and television producer and director. Indeed, one of the first films I directed was about the revolution in DNA science (*A License to Breed Money*, 1981). It featured the birth of a new start-up called Genentech[4] – one of the first genetic engineering companies - that today is a massively successful pharmaceutical company with its own campus and gigantic manufacturing facility.

Of course, not all my films have a connection to DNA; but nevertheless over my film-making career the molecular science of life is something I have returned to again and again, either directly or indirectly. So for the purposes of this paper I have focused on these films to explore the contrasting visual and structural techniques I have used to create a compelling narrative. What follows is an account of what I have learned over thirty-five years of making science documentaries, using clips from my films. Hopefully, it will encourage others to develop new and original ways of telling these important stories. There is no shortage of fascinating science stories to tell. The challenge is to find interesting ways of bringing them to life.

The Examples

Whether it's a feature length documentary or a one-minute short, the challenge facing a filmmaker is to develop a narrative that works. One classic way of doing that is to have a riddle or a mystery that is not resolved until the end. The first example of this technique is from a series of very short one minute films produced for the BBC's Science Week around twenty years ago. Yet they still stand up as intriguing little puzzles. The series of films was called *Conundrum* (1995). The idea was to describe something familiar in a very unfamiliar way using scientific language to define and describe the object. It's like a recipe where you reveal the ingredients of a dish without naming the dish until the end. Or imagine writing

4. <http://www.gene.com/media/company-information>

a patent for an object– while keeping the identity of the object hidden till the final frame. For instance, in a single continuous motion control shot that flies over a series of objects and actions illustrating a combination of chemical elements; then they are mixed together and 'baked'; and then in the final frame the lid of the cooking pot is lifted to reveal a baby.[5] The recipe was a precise breakdown of the percentage of each chemical element found in the human body. And the moment when the lid is lifted is quite a surprise the first time you see it. This one-minute film is an example in miniature of how a classic story unfolds: first you tantalize the audience, then you intrigue them as the story evolves, and finally you resolve the story with a dramatic pay-off. This can be summarized in three steps: **tantalize, evolve, resolve**.

I should say that I do not like being too prescriptive about story-telling. I have always been slightly wary of the highly popular story-telling seminars attended by a generation of science producers in recent years, because I think it can lead to formulaic storytelling and thinking. Sometimes quirks and diversions can enrich a story. Nevertheless, a film is a linear construction and there are some useful lessons to share in constructing documentaries about science.

One of the least satisfying forms of science documentary is the survey film, where you take a subject and then try to assemble a set of modules that give an overview of the subject. There is a surprising number of these films – and with some notable exceptions – most of them are very forgettable. They deliver clear information, but lack any emotional involvement or story, so they fall flat.

Sometimes you see exciting developments in an area of science and technology – and you want to capture the buzz of that revolution. A good way of doing that is to carry out a wide trawl and then identify a place to dig deeply. The result can be a more profound insight into the bigger story. Back in the 1980s, the editor of the BBC's flagship science series, *Horizon*, was eager to commission films about the huge implications of genetic engineering and DNA science. So with this in mind, two young producers (Oliver Morse and myself) set off on a grand tour of the most important labs in the USA and Europe. We took a crash course in molecular biology. We came back excited by what we had found out – but completely overwhelmed. It was a daunting task to identify any narrative in what we had experienced. The science was extremely tough to explain and in the immediate future the consequences seemed quite remote from people's lives. It really focused our minds on what would make a good story. DNA science is intangible stuff – remote from most people's experience. So how could we engage an audience? In the end we proposed two very different films: *The Cline Affair* (1982) and *Brave New Babies?* (1982). Both were broadcast in the early 1980s and both very much reflected the uncertainties of the time.

5. <http://vimeo.com/108993642>. A second example *(Clarinet)* of the same technique is shown in this clip.

The Cline Affair (BBC *Horizon*, 1982)[6]

Science can be a heroic pursuit, but like any other human endeavor it is prone to human frailties and ambition. There was a lot of suspicion about the wisdom of genetic engineering thirty years ago, so to carry out an experimental treatment using recombinant DNA was highly controversial, particularly when it was done without the full informed consent of patients. *The Cline Affair* was a moral tale that provided an indirect, but compelling way into what was possible with the new recombinant DNA technology.

This film has a strong narrative structure. It begins by drawing you in to this character – Dr. Martin Cline, a highly ambitious and brilliant UCLA physician – and then it teases you with the fact that he has done something wrong, something deceitful, something that will almost destroy his career. So there is tension from the start – and the viewer will be judging this man's actions.[7] This provides a motivation to follow the story and offers something that is quite rare in films about science – dramatic tension. Yet to appreciate the twists and turns of this story – you need to understand the principles of the science portrayed. Consequently there's lots of science in this film: from the role of globin genes, to the use of genetically engineered bone marrow stem cells to treat Thalassemia. But the science is only introduced at the point in the story when you need it to judge the moral dilemma facing this man. This stealthy drip-feeding of science allows the viewer to become absorbed in the story and not feel they are watching an educational film. Only scientific explanation that is essential to propel the narrative forward is included. If you are trying to make an informed judgment about this physician, then this is vital. Gradually, you shift from feeling his actions are justified to feeling he has over-stepped the mark. There is no clear-cut right or wrong – and that's what keeps the drama of Dr. Cline's situation interesting. You can feel his frustration and see his dilemma. What drives this film is not the science, but the tragedy of a man embroiled in his emotive reaction to the science. The art of this kind of story-telling is to make the audience see the world through his eyes, so they can judge for themselves his motives. He felt, given the terrible nature of this devastating genetic disease, he was justified in going ahead with his recombinant DNA treatment. But do you believe his motivation? Does the end justify the means? As you hear his justification you feel a mixture of empathy and outrage – and so, there is ambiguity to the end.

Brave new Babies? (BBC *Horizon*, 1982)[8]

The Cline Affair had a natural narrative. The second film about the rights and wrongs of genetic engineering, *Brave new Babies?*, was more didactic. It was built around the musings of a moral philosopher called Jonathan Glover[9] who set out to investigate the subject. His

6. <http://collections-search.bfi.org.uk/web/Details/ChoiceFilmWorks/150107896>
7. <http://vimeo.com/108993864>
8. <http://www.worldcat.org/title/brave-new-babies/oclc/66796464?referer=di&ht=edition>
9. <http://www.jonathanglover.co.uk/>

journey provides the framework for the film. He visits scientists, families and other people whose lives might be affected by the new technology. The difficulty with using these encounters as an underlying structure is that you are stuck with the chronology of the order of characters he visits. So the arguments need to be well prepared.

As so often happens in making documentaries, serendipity plays a part too. On the first day of filming we stumbled into an amazing scene – that we knew was something extraordinary. After breakfast Jonathan's children were engaging their father in exactly the kind of debate that was dividing people's views on genetic engineering. So we started filming. Their discourse became a continuing thread through the film.[10] The older of the two brothers, Daniel, aged 11, was pro-genetic engineering and thought that parents should have the right to choose the characteristics of their children; while the younger brother, David, aged 8, thought tampering with nature in this way was wrong. Here were the philosopher's children discussing DNA – their own genes and upbringing shining through.[11]

Wanted: Butch Cassidy & The Sundance Kid (NOVA/Channel 4 True Stories, 1993)[12]

DNA continued as a connecting thread in my films sometimes appearing in the most unlikely places. As DNA finger printing evolved it became more widely used in forensic investigations. It also became an investigative tool in historical documentaries. In 1993 I made a film called ***Wanted: Butch Cassidy & The Sundance Kid*** that followed in the footsteps of the two legendary outlaws to find out what really happened to them. Forensic anthropologist, Clyde Snow, led a team of scientists down to Bolivia to try to locate the graves of the outlaws, exhume their bodies and extract DNA from the bones. The film triggered a new genre of scientific adventure stories in the 1990s that traveled to exotic places with a mission to find something out.

The narrative of this film has two complementary threads that are carefully woven together. The first is the original story of the outlaws. This was told using Clyde Snow and outlaw historian, Dan Buck[13], as surrogate Butch & Sundance figures, who have a rapport and sense of humor echoing the characters played by Paul Newman and Robert Redford in the original movie[14]. The second is the archaeological and scientific investigation led by Clyde Snow.

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10. <http://vimeo.com/108994823>, 00:00 to 03:16.

11. Twenty years later David Glover would work with me on a series to celebrate the 50th anniversary of the discovery of the DNA (see below in the paper) and would then go on to become Commissioning Editor for Science at Channel Four (2005). See: <http://www.broadcastnow.co.uk/news/commissioning-old/david-glover-channel-4/5004646.article>

12. <http://www.windfallfilms.com/show/1222/Wanted+Butch+Cassidy+and+The+Sundance+Kid+.aspx>

13. <http://theappendix.net/contributors/profile/daniel-buck>

14. *Butch Cassidy & The Sundance Kid* (George Roy Hill, 1969). <http://www.imdb.com/title/tt0064115/>

He narrates the film as a personal odyssey in his distinctive Oklahoma drawl. A motion control rostrum shot tracking over various personal possessions and old photographs suggests Clyde's colorful past and credentials.[15] As the dig in Bolivia progresses and they dig up 'gringo' bones, the scientific investigation begins. Clyde calls together a group of experts to assess the evidence in a classic Sherlock Holmes de-brief. The narrative is told in the style of a Western and a detective story, yet their analysis reveals more about the scientific method in action than any film I have made. This is a film that contains a huge amount of science – but again, it is introduced almost by stealth at points in the story where it is needed to solve the mystery. There is never any sense of a 'science lesson'. I never assume the viewer is interested in science per se. I try to show how science can help answer interesting questions – a necessary tool for the curious.

Ten years on and DNA reared its head again as we drew near the 50th anniversary of the discovery of the Double Helix in 2003. I then approached PBS and Channel 4 to see if they wanted a series that celebrated the extraordinary progress of DNA science over the last 50 years. A lot had happened in the 20 years since we had filmed the young David Glover on the sofa discussing the pros and cons of genetic engineering. Now David was a young, talented filmmaker himself and he worked on what would become an Emmy-award-winning series, called simply, *DNA*. Now the challenge was even more daunting - to pick the right stories to tell in this epic saga.

DNA (Channel 4/PBS, 2003)[16]

The hero of our series was a molecule. Was that possible? Up to a point. But to appreciate that hero we also needed to identify key characters and stories. Much like this paper, I decided to adopt a chronological approach. It is the classic narrative structure. Each film was to be a distinct chapter covering a specific theme. We also wanted to have key characters appearing in several films – and the obvious central character was Jim Watson, who remained at the centre of DNA science all the way through. The first film looked at the original discovery, the second at the advent of genetic engineering, the third at the human genome project, the fourth at DNA's impact on cancer research, and the final program was Jim Watson's vision of the future of DNA.

The story of the discovery of the double helix is well-trodden ground. There's the book[17], the drama, *Life Story* (1987)[18], and many documentaries about this famous event. Our approach was to take Jim Watson back to Cambridge and to King's College, London. In the first film, *The Secret of Life*, we see him sit in the lecture theatre where he had sat 50 years

15. <http://vimeo.com/108997683>
16. <http://www.windfallfilms.com/show/1117/DNA.aspx>
17. *The double helix* (Watson, 1968).
18. *Life story* (BBC, Mick Jackson, 1987). <http://www.imdb.com/title/tt0093815/>

before, listening to Rosalind Franklin's X ray crystallography results – and where he was shown the infamous photographs by Maurice Wilkins. It's an intimate film following an old man reassessing the most important moment in his life.

In the second film about the birth of genetic engineering, *Playing God*, we look back at the public concerns about the potential dangers of recombinant DNA. In 1975 a group of scientists, lawyers and physicians got together at the Asilomar Conference in California to discuss what should be done. Again, we took back key participants, Paul Berg and Jim Watson, to the conference centre on Asilomar State Beach to re-live the debate. Taking people back to the scene of an important event in their lives often works well in documentaries. It helps jog memories and also provides a visual backdrop to evoke the history of that time.

In this second film, we also wanted to show the incredible progress of genetic engineering in recent years - to bring the film completely up to date. We needed some way of encapsulating the way this lab bench science had turned into a massive industry. The scale of modern plants, like the manufacturing facility at Genentech in Vacaville is jaw dropping.

But how do you encapsulate this in a short sequence? The art of compression and distillation is vital in such circumstances. When we arrived to film, we were presented with their Head of Manufacturing, who had a limited amount of time and was expecting to give a short interview with a stainless steel vat as a backdrop. We were after something much more ambitious – which gave an idea of the enormous scale of the place. So I suggested he take us on a lightning tour of the facility. We would put the camera on a dolly and chase after him, keeping the camera rolling all the time, and then he could go back to work. He begins at the entrance by saying: "Welcome to Genentech!" and then we set off on this journey with running commentary round the plant, chasing him along corridors, into elevators and through vast warehouses and manufacturing plants. In the final edited sequence which is compressed, but continuous, we crank up the scene in fast-forward, selecting only key bits of his commentary and slowing down only for short bursts of sync sound.[19] The result is a highly energetic whistle-stop tour of the facility – a very short sequence that encapsulates the scaling up and production of a genetically engineered drug.

The third film, *The Human Race*, focused on the race to sequence the Human Genome. The use of a race between two rival research groups is a familiar narrative structure in science films. In this case it was a race between two different philosophies as well – the publicly funded group, led initially by Jim Watson, and then Francis Collins with John Salston; and the privately funded group led by scientist and entrepreneur Craig Venter. This battle between the public and private groups became so bitter that President Clinton had to intervene as a peacemaker.

Finding pictures to support dramatic stories from the past always poses problems for documentary makers. In this film about the human genome project we had virtually no

19. <http://vimeo.com/108997883>

archive pictures – and most of the crucial research work was data crunching on computers. (There are only so many sequencing machines you can show.) We liked the story of the 'hippy' programmer in California taking a break from more lucrative gaming programming, to help number crunch the data from both sides of the Atlantic – working late into the night in his shed. To visualize this we used Super-8 film with a heavily saturated color grade to give a slightly 'acid trip' tone to his nocturnal antics.[20] But the real challenge in the story telling was to explain what the scientists were doing.

In order to appreciate the enormity of the task of piecing together millions of fragments of DNA into the complete human genome, we needed to use CGI. Integrating graphics into science films is hard to do without making the film feel educational. If it is badly done, it can upset the tone of the story telling, but sometimes ideas are so complex, graphics are the only way. This was going to be a problem throughout this series, so we built a set – a stage on which all the CGI for all the films would play out. The set was a 1950's lab, which is used in the first film as a backdrop for illustrating base pairing in the double helix; in the second film for showing recombinant DNA, and in the third film for demonstrating the huge amount of data generated to read the four-letter code of the entire human genome. We used huge piles of paper that were stacked impossibly high into vertical space above the lab bench and explosions that shattered the papers into tiny fragments. The use of the lab set as a backdrop for all explanatory graphics became a defining device of the series and helped maintain the narrative integrity throughout.[21]

In the final film of the *DNA* series, *Pandora's Box*, we follow Jim Watson on a more personal journey to consider the future of DNA, against an emotive backdrop of eugenics, genetic testing and gene therapy. At the beginning of the film we capture the essence of Jim Watson's controversial character – the devilish delight he takes in challenging orthodox views. This sets up a remarkable personal odyssey in which he confronts some of the questions and concerns that DNA science raises about the future of humanity. In many ways this was the most difficult narrative to construct, because there is no natural chronology, yet it ends up being the most emotionally powerful of the films. You travel with this much-misunderstood man, who made one of the most important scientific discoveries of all time and discover what he thinks. The molecule – DNA – sits at the centre of all the arguments. Yet, following an individual on an odyssey is another powerful story-telling device, particularly when they are asking a big question and set off on a mission to answer it.

20. <http://vimeo.com/109000198>

21. <http://vimeo.com/109001864>

Do You Want To Live Forever? (Channel 4, 2007)[22]

In '*Do You Want To Live Forever?*', computer scientist, Aubrey de Grey has a passionate belief that biological science may be able to save us from getting old. Most scientists remain skeptical, but the quest to find out whether he is inspired or deluded forms the basis of an eccentric road movie directed by Christopher Sykes that delves into this character's psyche. We first meet Aubrey in the Eagle, in Cambridge, the pub where Watson and Crick celebrated their double helix discovery. From this initial introduction you feel uncertain about whether to believe this man – but this is a crucial part of the film's underlying dramatic tension.

The pre-title 'tease' at the start of the film is a great example of an enticing introduction – which sets up the proposition perfectly and introduces an eclectic cast of characters.[23] During the course of Aubrey de Grey's journey, he meets scientists and technologists from many different disciplines that give the viewer an intriguing insight into the science of ageing. Aubrey wants to bring these people together in the hope of cross-fertilizing ideas that might mean that science can halt the ageing process. Many scientists view Audrey as a heretic, but as the film progresses you want to know what drives his mission. Why is he so desperate to find the elixir of life? The film has a wonderful 'Rosebud' ending where you discover the final piece in the jigsaw of what might motivate Aubrey in his quest for eternal life. The suggestion is that it was a love story all along – and that the driving force behind his passion is his partner, who is older than him. He wants her to live forever, like him. This is a quirky film, but it does offer an insight into the current state of scientific understanding of ageing in a non-didactic way. It is a film with emotional undertones that make you laugh and cry as the narrative unfolds.

Your Inner Fish (PBS/Tangled Bank Studios, 2014)[24]

Some of the most difficult stories to construct are based around a high concept idea with no obvious linear narrative and lots of potentially diversionary back-stories. This was the case with my most recent science series, based on a book by Neil Shubin[25], called *Your Inner Fish* (2008). The idea is to trace parts of your body back to your ancient animal ancestors – 'meeting the family you never knew you had.' To do this, the film draws on paleontology, developmental biology, comparative anatomy and DNA science to find links with our past. This was a highly ambitious series that tested story telling to the limit. The series was broadcasted on PBS in 2014 and had three parts: *Your Inner Fish*, *Your Inner Reptile* and *Your Inner Monkey*.

22. <http://topdocumentaryfilms.com/do-you-want-to-live-forever/>.
23. <http://vimeo.com/109004589>
24. <http://www.pbs.org/your-inner-fish/home/>.
25. <http://pondside.uchicago.edu/oba/faculty/shubin_n.html>

Unlike a book, which is conveniently divided into chapters, film is a relentlessly linear medium. There were several components to this story: an expedition to the Arctic in which Neil Shubin discovered a transitional fossil fish called *Tiktaalik*, one of the earliest fish to do 'push-ups' on to land; an evolutionary development story illustrating the DNA links between fins and limbs; and the human anatomy story that compares the bone structure of our hands to the fins of fish.

This is essentially an evolutionary biology tale, but to tell it chronologically would not be very interesting. In this case I wanted to take advantage of the rather surreal idea that there is an inner fish within us all; and that the evidence for this is in our bones and our DNA. I also wanted to give the series a setting – which in this case was the city of Chicago, where Neil Shubin works. The opening of the film begins on a Chicago subway train with Neil looking at his fellow passengers as they transform into a monkey, a reptile and a fish. In the reflection of the train window he sees the Tree of Life unfolding. Immediately we are inside Neil Subin's head and it is a quite funny place to be.[26] I wanted to reflect his humor in the films. You want to be with this man and hear his stories. His passion and intensity shine through and that's what draws you into the difficult subject matter.

One of the first scenes takes place in the dissection room of the Chicago Medical School where he teaches. He tells the story of the first time he dissected a human hand. It is a surprisingly poignant moment, which transforms into a sequence about hand anatomy. Immediately you are presented with the riddle of how the human hand evolved from the fins of fish. There are several quirky scenes, such as 'My wife's a fish' – a scene where Neil calls in on a neighbor who shows him the remnants of a gill structure behind her ear. These comic interludes have a serious purpose – to demonstrate the developmental processes that can occasionally reflect vestigial bits of anatomy from our 'fishy past'.

As well as being an anatomist and developmental biologist, Neil is a fish paleontologist. One of the major strands through the film is his search for this transitional fish fossil that made it on to land. We took him back to the Canadian Arctic where he found this fossil, but rather than run this as one complete story, in the final film we kept returning to it, culminating with the actual discovery of *Tiktaalik*. This helped build up to the climax of the discovery, but it also allowed us to integrate the second 'evo-devo' strand through the film. The film culminates with an epic CGI sequence in which we see a series of embryonic creatures gradually making the transition from fish fin to human hand that draws the two strands of the narrative together.

26. <http://vimeo.com/109002768>

Conclusion

I've looked back at some of the story-telling approaches that have worked for my films – and in doing this I've constructed a narrative that has DNA at its heart. Twin strands have been a recurring theme throughout. I'm drawn by the aesthetic appeal of the double helical structure of life, and by examining the underlying structure of these films that share DNA in different ways I've tried to demonstrate some of the story-telling techniques I've used in the past.

These techniques include: the classic scientific detective story, using a moral dilemma as a sub-plot; a race to be the first to discover something; a personal odyssey driven by a central character; and a riddle or mystery that is only resolved at the very end of the film. For each of these approaches finding characters that display conviction, passion and a sense of humor is often crucial to the success of the film. Then the challenge is to identify a narrative structure that suits the subject matter and reflects the character of the participants.

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FORMAL CONVENTIONS IN BRITISH SCIENCE TELEVISION, 1955-1965

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Abstract: *This essay considers two significant subgenres of British television science coverage in the foundational period 1955-1965, looking in detail at the series* Look *for natural history and* Eye on Research *for the sciences more broadly. In each case, I consider the contributors to the programmes, both producers and participants; the origins of the programme; and formal aspects, to consider how the series related to their predecessor and successor programmes. In each case I consider where the authority of the account of science rests in the programmes. In alluding to what came after these two series, I introduce some first thoughts about the role of the scientist-presenter in science television.*

Keywords: *Science on television, documentary films, popularization, science communication, film techniques.*

Resum: *Aquest assaig considera dos subgèneres significatius del reportatge de ciència a la televisió britànica en el període fundacional 1955-1965, mirant en detall la sèrie* Look*, d'història natural, i* Eye on Research*, de ciències en general. En cada cas, prenc en consideració els col·laboradors dels programes, tant els productors com els participants; els orígens del programa; i aspectes formals, per tal de veure de quina manera les sèries tenien relació amb els seus programes predecessors i successors. En cada cas, considero on rau l'autoritat del relat científic en els programes. En*

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al·lusió al que vingué després d'aquestes dues sèries, introdueixo algunes primeres reflexions sobre el paper del científic-presentador en la televisió de ciència.

Paraules clau: *ciència a la televisió, documentals, divulgació, comunicació científica, tècniques cinematogràfiques.*

Introduction

Recent work on the history of science on television is beginning to reveal the key features of the earlier postwar period.[2] The reasons for looking at the two decades to the mid 1960s are clear because, as the producer Norman Swallow said at the time, 'during those … twenty years [television] has forged its own techniques, developing its own form of journalism, and learning the best ways of presenting the world to the world'.[3] In other words, these decades were formative for the establishment of the conventions of television and, we might add, within the wider range of non-fiction programming, of science television. In forging those techniques, television producers drew to varying extents on existing approaches from filmmaking and radio (Bell, 1986), which themselves encoded particular approaches to the sciences.[4] Previously I have considered whether individuals who moved from documentary filmmaking into television acted as vectors for the formal conventions of filmmaking into television style (Boon, 2013). In this essay, I broaden the questions discussed there by presenting and contrasting two aspects, concentrating more on what was presented to the viewer's eyes and ears, and especially on the personalities of science television.

Institutionally, BBC television separated natural history television production (by centralising it at their production facilities in Bristol) from that devoted to the remainder of the sciences, which between 1957 and 1963 became increasingly centralised under what became the outside broadcast features and science department in London. Accordingly, in my first section here I consider the roots of natural history television in the conventions of natural history filmmaking, via the series *Look* (1955-68[5]), where amateur expertise was the order of the day. Second I consider the very different coverage of the sciences in the series *Eye on Research* (1957-62), whose roots and style were very different and where the staple was professional science. The comparison points to the very different cultural placing of natural history and the remainder of the sciences, a tendency that may well have been reinforced in the broader culture by these televisual representations. There remain, however,

2. For example: Boon (2008); Boon & Gouyon (2015); Boon (2014b); Lafollette (2013); Gouyon (2011).

3. Swallow (1966), inside front dust jacket blurb.

4. It would be valuable to explore the relationship between radio conventions and those in television's coverage of science, as several key individuals graduated into factual television from radio. I am grateful to Allan Jones for making this suggestion. Unfortunately it is not possible to include this within the scope of the current paper.

5. The end date is not absolutely clear, although on current evidence it seems that after 1968, issues of *Look* were repeats. This is the implication of Parsons (1982: 263), and also of Peter Scott's BBC contract file WE8/541/1.

some formal similarities between the approaches of the programmes; these are explored by a consideration of the sources of authority in the two forms, and at the end a glance at the programmes that succeeded these two foundational series.

Case One: Natural History Television, Amateur Expertise and Filmmaking

Peter Scott, the ornithologist and television presenter, tells the story in the foreword to PS Crowson's 1981 history of Oxford Scientific Films (OSF) of how he was visited in 1959 by an entomologist with a number of still photographs of parasitic wasps. 'Still photographs are excellent for books. Television, as I pointed out to Gerald Thompson, requires moving pictures' (Crowson, 1981: vi-vii). According to the story, this was the founding moment of OSF, which went on to become one of the most significant players in natural history television. It also conforms with one of the primal stories of natural history cinematography. Wind the film back 51 years and witness a similar encounter: in 1908, the film pioneer Charles Urban was looking for a successor to Francis Martin Duncan, the naturalist who had spent five years making animal and microcinematographic films for him. The story is that Urban was shown a photograph taken by the amateur naturalist Percy Smith of a fly's tongue. The two men met in May 1908 and Urban gave Smith the use of a cine camera. According to the story, on these origins Smith became the doyen of British naturalist-cinematography and a minor celebrity of the 1920s and 1930s (McKernan, 2013: 58; McKernan, 2004).

Peter Scott's authority to write the foreword to Crowson's book derived in part from his renown as the presenter of *Look*, broadcast by the BBC between June 1955 and 1968, which was the first regular natural history programme on British Television. Its established format was to show films made by a range of specialist naturalist-cinematographers, interposed with studio introductions and discussions. The *Radio Times* listing for the first programme on June 14th 1955 gives the tone: 'Introduced by Peter Scott / Heinz Sielmann introduces his own film of foxes in the wild' (Anonymous, 1955a: 21).[6] Other filmmakers included Walter Higham, Lord Alanbrooke, Bernard Kunicki and HG Hurrell. The producers were also 'happy to see and assess the suitability of material from all possible sources', sometimes running competitions for new footage (Kendall, 1970). *Look* may be seen as a transitional object from established traditions of natural history making towards the forms that overlapped with and superseded it, including *Zoo Quest*, *On Safari* and David Attenborough's later series.[7]

The origins of British natural history filmmaking for paying audiences of the general public lie with the American entrepreneur Charles Urban, and the first programme of such

6. The series under the name *Look* built on the success of *Peter Scott: Woodpeckers*, an earlier Sielmann-based programme with the same format broadcast 15 January 1955.

7. This essay does not *look* at *Look* in relation to the broader development of natural history television as popular science, as that job is well done by Davies (2000), Cottle (2004) and Gouyon (2011).

films at the Alhambra Music Hall, Leicester Square in August 1903 (Boon, 2008: 7-9). One-reel animal films, often concatenated into sequences, became features of Urban's catalogues from this date, and certainly films of plants and animals were part of the swell of popular subjects that converted cinema from a fairground novelty into an established form with its own specialist venues by 1910. But the main point of comparison I wish to draw here is with two series run by H Bruce Woolfe, *Secrets of Nature* (British Instructional Films, 1922-33) and *Secrets of Life* (Gaumont-British Instructional, 1933-45). These erratic but highly popular series did for the cinema and classroom, at least on the surface, exactly what *Look* later did for the television: they provided a platform for skilled cinematographers to show their work and earn some kind of living. Woolfe commissioned Charles Head, Oliver Pike, Captain H A Gilbert and Walter Higham, and most prominently, Percy Smith, to provide footage; of insects, birds, small mammals and plants. Mary Field, a history don, joined British Instructional in 1926 and the next year assumed the editing and production of the series from the supplied footage as well as making films at London Zoo (Powell, 2004). By 1933 there were close on 150 *Secrets of Nature* films, and a similar number of *Secrets of Life* items were made between 1933 and the outbreak of war. Generally the films were about nine minutes in length, and they most often followed the life cycle of whatever plant or animal they featured. Natural history continued to be a popular subject for filmmakers after the War; one example is the series, *The World of Life: A Journal of the Outdoors* (1952 to 1961), which featured a variety of animal and zoo-based stories.

The question arises of the extent to which the team responsible for *Look* was aware of the historical precedents for their practice. There are some obvious indications; one example is the inclusion of occasional historical programmes, including *The Start of it All*, the title of the *Look* edition of 12th December 1958, which told the story of Cherry Kearton, who had started making wildlife films in 1909. We may discuss this question further in three ways: via its producers and contributors by considering television personnel and filmmakers employed for *Look*; via origins, by looking at the Gerald Thompson story again; and via preferences over the form, both of the programme and of the submitted films, by paying attention to the advice given to contributors. These will be seen to help us understand the sources of the authority of the programme.

Desmond Hawkins, who had established his reputation making radio nature programmes from his base at BBC Bristol, was the producer behind the establishment of the series *Look*, as well as the chief proponent of the Natural History Unit. Attenborough credits him with such determination to establish natural history on television, that despite the absence of TV studios in Bristol at the time, he achieved the first *Look* programmes by converting a sound studio by adding an Outside Broadcast Unit (Attenborough, 2003: 60). Hawkins, in this account, exemplifies two separate features of the foundational decades of BBC television: origins in another medium (most often radio and documentary filmmaking are cited, though some journalists started in newspapers); and an ability to 'manoeuvre' with the

attributes of being 'a wily operator … skilled in BBC politics' (Attenborough, 2003: 60). Over the 13 years in which the programmes were made, many BBC producers took a hand in production of the series, including Jeffrey Boswall, Nicholas Crocker and Eileen Molony, all BBC staff.[8]

A decisive link between the prewar films and *Look* is the presence of some of the same filmmakers. Walter Higham, for example, a specialist in filming birds who began experimenting with nature filmmaking in 1917, made films for Woolfe at least as early as 1931, when his contributions *The Short-Eared Owl* and *The Bittern* were put out as *Secrets of Nature* (Field & Smith, 1934: 39-43, 242). He became a frequent contributor to *Look*, for example with his film *The Land of the Flamingo* (9 August 1955) (Anonymous, 1955c: 15; Anonymous, 1955d: 26). *Look*'s 78th episode was devoted to *The Best of Walter Higham* (21 April 1961), featuring footage from 1925 and profiling his long career (see below). A slightly different example is that of the Imperial College zoology lecturer Humphrey Hewer, who featured in the programme on 12 July 1955, showing footage of Atlantic seals (Anonymous, 1955b: 21). Hewer had in 1933 been brought in by Julian Huxley to Gaumont-British Instructional to assist in giving scientific oversight to the biological films the firm began to produce (Hewer, 1946: 16-17). In these examples we have the two poles of natural history filmmaking; the amateur naturalist who worked through the medium of film to convey what he saw, and the professional scientist who became convinced by the teaching potential of film.

Beyond these links of personnel, there are examples of definite genealogy, for example in the longer version of the founding story of OSF sketched above. The proposal to make films came from Eric Skinner, Thompson's technical assistant in the Department of Forestry at Oxford University, who had started there in 1924. Thompson began taking still photographs of insects in 1955, but was finding that they weren't ideal for teaching; 'I was chatting to Eric on this particular morning, complaining that stills, although they're very nice, did not really give me what I wanted. I wanted to be able to show other people how these insects behaved, and he said, "Well, what we really need is a cine film"' (Parsons, 1998). Skinner explained to his boss that before the War he had been charged with taking live wood wasps and their parasites to Percy Smith, who at the time was making his Secrets of Nature film *War in the Trees* (1931), which was narrated by Thompson's Oxford predecessor, Dr Neil Chrystal.[9] Crowson recounts: 'so Thompson borrowed a 35mm film projector … and on Thursday, February 5th, 1959 [note the stress on ur-moments], showed one of Percy Smith's films. Gerald saw at once that films were the best means for teaching students

8. *Radio Times, passim*; BBC Staff Lists (Set kept at BBC Written Archives Centre, Caversham)

9. See Field & Smith (1934: 97-103) for Smith's account. Sequences from this film can be viewed at http://www.britishpathe.com/record.php?id=75390. Thompson is keen to assert that it was a different *species* of woodwasp; see Parsons (1998).

how insects behave and how their bodies work' (Crowson, 1981: 19). The Departmental librarian, being visited by Bruce Campbell from BBC Bristol, mentioned Thompson's photographs, a comment that led to the visit to Slimbridge that Scott recalled. *Look*'s 'appetite for good film [was] almost insatiable', so the BBC – in conjunction with the Council for Nature – ran competitions for suitable films in 1960 and 1962 (Campbell, 1962). Thompson and Skinner entered the film they had been making all year since May 1960, *The Alder Woodwasp and its Insect Enemies*, which won the two top prizes. It was broadcast on *Look* on 19th May 1961 (Crowson, 1981: 19-21; Parsons 1998).[10] OSF personnel contributed very many more films to the BBC over the succeeding years.

The advice sent to competition entrants also shows one of the direct links between *Look* and the older films. These documents combine technical with narrative recommendations, adding up to prescriptions on acceptable form. For example, in 1962 the 'notes on filming' included:

> 1. Shoot at 24 frames per second.
> 2. Try and keep in mind the general story the film has to tell, and wherever possible, think in terms of sequences of pictures and how the one sequence has to be linked with the next pictorially. …
>
> Principally we are looking for (a) Film showing as much as possible of the life history of any one animal in its natural habitat – its behaviour in the widest sense in a number of typical circumstances and its relation to the environment and other animals (Anonymous, 1962).

This emphasis on narrative structure continued; in 1970, for example, the BBC Natural History Unit 'basic guide for cameramen' advised:

> To produce the correct sort of coverage it is best to concentrate on completing 'action' of certain behaviour, ie feeding, grooming, leaping, parental care, and so forth. One must try and concentrate on correct sequence building with establishing wide angles, long shots intermediate and intimate close ups, and variation of angle throughout are all important. Equally important is 'allowing' the moving subject to pass clearly out of shot before 'running out' on it (Kendall, 1970).

Such narrative demands about what makes 'good television' are clearly to do with conventions rather than with ideal categories. Early natural history films, such as Duncan's *Cheese Mites* (1903) or Smith's *Birth of a Flower* (1910) did not have such structures, but these were conventions that were well in place by the time that Mary Field and Percy Smith

10. Several clips are available at http://www.wildfilmhistory.org/. See also Parsons (1982: 113,114).

published their book *Secrets of Nature* in 1934. Here Field, promoting correct practice on the basis of a much shorter history – perhaps 21 years – laid out the principles of what made a good film in her view; I have selected items from her sophisticated chapter on editing that relate to the foregoing:

> A film is essentially a story told in pictures … Before you can start to tell your story in pictures you must, first of all, have some idea of what your story is to be. …action should always work in the same direction in two consecutive scenes : if a water flea goes swimming across the film from left to right and goes out of the picture on the right side, in the next scene he must swim in on the left so as to continue his course from left to right. … The fact that each film deals with one particular life history or one particular aspect of Nature makes it difficult to vary the form of their presentation. Life histories move with depressing regularity from seed to seed or egg to egg… (Field & Smith, 1934: 188, 194, 204)

These three aspects – the filmmakers involved, the origins of the programme and the narrative techniques expected of contributors – show the strong continuities between the format of *Look* and the older tradition of nature filmmaking. Continuity is, proverbially, married to change, so it is unsurprising that there are also aspects of *Look* that differ from the older films; these are the marks left by the struggles to create effective forms of non-fiction television that had characterised the previous seven years at least at the BBC (Boon, 2008: 192-203). For example, the programme combined live studio presentation (in its early years from a studio mock-up of Peter Scott's base at Slimbridge) with telecined film inserts, a format developed as part of the BBC Talks and Documentary Departments' techniques in the years when television executives placed a special emphasis on the centrality of liveness to the televisual experience (Boon, 2008: 200, 207, 210-219).

Science television achieves much of its cultural effect by the authority that the people in front of the camera project. The conventions here differ from those in the majority of science documentary films up to the 1950s before they, in their turn, began to be inflected with televisual styles. As Paddy Scannell has argued,

> The liveness of broadcasting, its sense of existing in real time – the time of the programme corresponding to the time of its reception – is a pervasive effect of the medium. The talk that goes on in radio and television is recognisably … intended for and addressed to actual listeners and viewers. (Scannell, 1991: 6)

This intimacy of television, placing the stress on talk that is Scannell's concern, also requires the presence of people on screen doing the talking. The authority they project is a product of different factors within the televisual performance: person, bearing, expertise

and voice, all mediated by the televisual styles and conventions adopted for specific programmes:

> The design, layout and lighting of the studio; the age, appearance, sex and dress of participants; the manner and style of how they talk to each other – all these give rise to warrantable inferences about the event there taking place, the character and status of the participants and the relationship of event and participants to viewers. … the *grain* of the voice gives rise to inferences about the speaker; and changes in voice are an important means of creating [implied meanings]. (Scannell, 1991: 6)

In the case of *Look*, there were significant social factors – class, profession, age and gender – in the establishment of that authority. In the first place, Peter Scott, knighted in 1973, was well-known as the son of Robert Falcon Scott – 'Scott of the Antarctic' – and was a privately-educated unsuccessful conservative candidate in the 1945 election, who had famously established The Severn Wildfowl Trust at Slimbridge in 1946 (Walkden, 2004). The implication of the programme, reinforced by the set reproducing Scott's studio, is very much of the viewer being invited in to overhear a private film show with a well-informed voiceover from Scott, or from a range of other male, middle class, middle-aged presenters. This was at a time before the social revolutions of the 1960s, when such attributes were expected to convey authority and reliability in a way that only later became open to widespread questioning. Although the commentaries are mainly simply descriptive of the action shown, pointing out species, behaviours and details, the encoded expectation is that the speech carries authority because of the person of the speaker. The result is that, whilst the programme's title 'Look' suggests a mode of communication based on showing, the authoritative expert voice achieves a large proportion of the programme's effect in the more didactic telling mode.[11]

In the programme on Walter Higham,[12] for example, we see Scott in medium close-up, dressed in jacket and tie, reading links direct to camera, and describing two still photographs of Higham. These continue into voiceover commentary which establishes the range of Higham's subjects, starting with 1920s films of gull-egg collecting and *The Cuckoo's Secret* and proceeding to a wide variety of wildlife – mainly bird – cinematography. Scott speaks in descriptive mode: 'Here's Walter in the park at Clitheroe [standing, with breadcrumbs in his outstretched hand, with a bird feeding] … and as he says there's no magic in this, it's just

11. Opening of *Look*'s 78th episode *The Best of Walter Higham*, 1961: http://www.wildfilmhistory.org/film/85/clip/352/Pioneer+of+bird+filming.html. Descriptive sequence of English garden birds, from *The Best of Walter Higham*, 1961: http://www.wildfilmhistory.org/film/85/clip/353/Britains+birds.html

12. *The Best of Walter Higham.* An excerpt is available at http://www.bbc.co.uk/historyofthebbc/resources/horizon50/before- horizon

a matter of patience but it's rather nice … he's got a robin here, now Britain's national bird … there's a blue-tit … and a great-tit coming onto his hand. And here's a picture of a cock sparrow building a rather unusual open nest … and this is another unusual nest, a song thrush's nest on the ground…'

Compared with *Secrets of Nature*, the screen presence of Scott and the other presenters also marked a departure into a new specifically televisual form of unscripted – or lightly scripted – but authoritative mode of verbal address. In *Secrets of Nature/Life* first captions, then (generally scripted) voiceover, had represented the authorial presence. In a sense, going back to a naturalist being visible on screen might seem a return to the 'showman' approach in which Smith had appeared in Charles Urban's *Movie Chats* around 1918-22 'before the camera … the young man who is often seen poking the insects or handling the microscope' (Urban, 1920). Scott's presence, however, implied the trustworthiness of the gentlemanly man of science, where Smith's presence in a film such as *Percy Smith with Herons* from the Urban series, where he shins-up a tree and wears goggles whilst feeding the infant birds, was playful at the same time as it revealed its natural historical subjects.[13]

War in the Trees, unlike many *Secrets of Nature* films, has a mainly straight factual commentary; *The Strangler* (on the parasitic plant dodder, 1930), by contrast and more typically, takes the consistent facetious line that the plant is 'a born criminal', a tone that is reinforced by the light orchestral music selected for the series from 1930 (Smith & Field, 1934: 226-229). The commentary of *War in the Trees* and Thompson's *The Alder Woodwasp* have many similarities, both in terms of what is conveyed about the life-cycle of the two varieties of wood wasp and their parasites in the films, and in the mode of factual description of footage which both films use. The sequences of egg-laying by the wasps' parasites is very similar.[14] Consistent with the normal style of the series, *War in the Trees* does feature the occasional gag – the parasitic Rhyssa, partially grown, is described as looking 'very dignified, rather like a judge' – but this is the exception. In both cases, the authority of the films comes from the way that the male, descriptive, received pronunciation commentary – Thompson's for *The Alder Woodwasp*, and Chrystal to *War in the Trees* – reinforces the precision photography.

In total, *Look* exemplifies the principle I have termed 'the persistence of genres'; that approaches to filmmaking which were the products of particular historical circumstances become embedded as the obvious, proper or correct approach to the subject in question. This is the continuity, still to be found to some extent in the latest natural history television. The principal change between *Secrets of Nature* and *Look* is in presence of the presenter; that too came to persist – paradigmatically in the case of David Attenborough – as part of the common sense of what is perceived to make natural history television effective (Boon, 2008: 3).

13. This film can be seen on the BFI DVD compilation *Secrets of Nature* (released 2010).

14. http://www.wildfilmhistory.org/film/261/clip/876/Alder+woodwasp+egg+laying.html

Case Two: *Eye on Research*: a New Account of Science

If *Look* was the first longstanding regular natural history programme, its counterpart in the coverage of other scientific disciplines was *Eye on Research* (1957-1962).[15] Each week this programme reported on a particular field of science by interviewing scientists and technologists in their laboratories. The first, ten part, series included programmes broadcast from the Motor Industry Research Association, the Atomic Energy Research Association, and Manchester University (to meet the new computer, in the company of Professor Freddy Williams). One whole series of ten programmes in 1960, marking the tercentenary of the Royal Society, featured Fellows of the Society, those élite figures of the scientific establishment, including Martin Ryle, Max Perutz, John Kendrew and Nicholas Kurti. It was the use of outside broadcast that was distinctive about *Eye on Research* compared with earlier approaches to making science programmes, either as film documentaries (such as those in the *World is Ours* series) or studio programmes such as *A Question of Science* or *Frontiers of Science* (Boon, 2008: 204-207, 210-211). It was a current affairs approach to science; as Aubrey Singer wrote, introducing the second series:

> Nowadays science affects everyone. We cannot ignore the implications of the rapid technological developments. Research paves the way towards tomorrow's new industrial techniques and materials. *Eye on Research* is an effort to keep you abreast of the times, by people who are ahead of their times (Singer, 1958: 6).

The programme took live outside broadcast cameras to various research establishments, just as its sister programme *Your Life in Their Hands* went into hospitals (See Loughlin, 2000). Technically, it explored a niche created by the BBC's extensive purchase of outside broadcast equipment to cover regional sporting fixtures at weekends. The equipment was largely unused on weekdays, and so producers were encouraged to find uses for it. This led to programmes such as *Eye on Research*, which they called 'built OB programmes', that is those that didn't merely televise existing events with a logic of following what was happening anyway, but which used outside venues as studios for programmes constructed using the grammar of television. In discussing this series, we may use similar categories as employed above – contributors (producers and participants); origins; and formal aspects – to consider how this series relates to its predecessor and successor programmes. Here again, we will consider where the authority of the account of science rests in the programmes.

The genealogy of *Eye on Research* was much shorter than that of *Look*. For the ambitious outside broadcaster Aubrey Singer, it was in a direct line of development from *The Restless Sphere*, his breakthrough programme from earlier in 1957, a one-off special to mark the start of the International Geophysical Year, featuring a remarkable and ambitious total of three

15. This account extends that in *Films of Fact* (Boon, 2008: 215-221) and employs different examples.

overseas and two UK live Outside Broadcast feeds. Whilst 'built OBs' were not entirely new in 1957, previous incarnations of the form had been relatively unambitious; a curator tour of the Science Museum's new aeronautics gallery, for example (Boon, 2008: 199). Singer had fixed upon the IGY as the vehicle to pursue his televisual ambitions after James McCloy from the Talks Department had deemed it impossible to turn into television; where the studio-based producer saw difficulty, the outside broadcaster saw the opportunity to establish a new mode of television that would compete with studio-based programming.[16] In that sense, competition between the OB and the Talks departments, which had up to that point been the established home of science broadcasting, determined the dominant televisual form for representing science in the five years from 1957. Accordingly, in the case of *Eye on Research*, it was not a matter of continuing an old convention in a new medium, as we saw with *Look*, but of developing a successful 'production model' of science broadcasting on the basis of the *Restless Sphere* prototype.

The series was produced by a small core team with Singer as series producer; he brought in researcher and writer Gordon Rattray Taylor; and used producers drawn from the relevant departments in the BBC's regional offices, and directors, including Bill Wright and Philip Daly, in addition to the reporter on screen (the experienced current affairs reporter Robert Reid, well known for presenting the current affairs series *Special Enquiry* (Swallow, 1966: 72-7. See also Bell, 1986: 65–80; Corner, 1991: 42–59) in the first series, thereafter Raymond Baxter (Moss, 2010)). Indeed, the approach to science in *Eye on Research*, as might be expected for one conceived as the current affairs of science, meant a stress on the person of the on-screen mediator; the billings in the *Radio Times* consistently featured the name of the reporter prominently. The reporter was to be the viewer's proxy in relation to their subject matter, introducing the subject, questioning scientists, and simplifying and summarising their responses. Taylor had previously been a print journalist; Reid had both press and radio experience. The rest of the team came from television itself. As for the people other than presenters appearing on screen, each programme introduced a selection of scientists or technologists, all of them – unlike the amateur naturalists of *Look* – professional laboratory and university based workers. They are of varying degrees of articulacy and ease in front of the (live) television cameras. The performances vary from confident exposition, lecture-style, or in the manner of a laboratory director conducting a tour, to some performances being halting in delivery, technical expositions that positively require the intermediation of the reporter.

In terms of the programme's formal style, whereas *Look* started with existing naturalists' films and competitions to have more made, *Eye on Research* was intrinsically more journalistic; the planning for each series started with the team making a selection of potential programme themes, often via conversations with élite figures in science, such as David

16. Aubrey Singer oral history recording, BBC Archives by courtesy BBC History and Heritage.

Martin, Secretary of the Royal Society. These discussions led to meetings with scientists on the ground, then selection of a balanced list of subjects for each series, a list that was narrowed down by practical availability of OB Units across the country.[17]

Compared with the established natural history film grammar of life-cycle narratives, matched movement and the rest, as an Outside Broadcast, in *Eye on Research* the cuts between shots are the electronic switchings of 'vision mixing' between cameras, rather than the precision cuts of film editing. In some cases, camera movement was used to add to the televisual liveness, introducing a new speaker or new piece of equipment, by panning or tracking the camera in or out. The cuts in *Eye on Research* are often at the spatial and structural level of cutting between the rooms where individual speakers are placed, as much as between, long shots and close-ups, for example. The cuts are generally fewer and more occasional than the more frequent edits of documentaries made in advance on film. Especially in older programmes, the picture sometimes loses synchronisation on a cut before the picture stabilises again – this technical difficulty may also have led to a disinclination to make more cuts within a programme than was strictly necessary. The result reinforces a tendency for sequences of exposition that last for minutes without the fine texture of visual variation which had become normal in film editing, not just in the ways that we have seen recommended for *Look*, but also in other traditions deriving from Russian experiments of the 1920s that emphasised the role of editing in the construction of cinematic meaning (Boon, 2008: 47-49).

To grasp the style of the programme, we may take the example of *The Six Parameters of P.A.T.* (28 Oct 1958) from the second series, produced by Alan Rees, an OB Producer based in Glasgow, from a treatment / script by the usual writer, Gordon Rattray Taylor.[18] The programme is concerned with the parametric artificial talker (P.A.T.), a speech synthesis device developed at Edinburgh University. It starts with the reporter Raymond Baxter in medium close-up, speaking to camera introducing the Edinburgh programme from London. The series titles follow (an oscilloscope showing the waveform of the theme music played on acoustic guitar as the title is superimposed). Next we see two men (Peter Strevens and Tony Anthony from the Edinburgh Phonetics Department[19]) in front of the bank of machinery that we infer is the 'Pat' of the title, which is intoning the name of the programme. The next sequence is a halting, half-read, preamble by (Walter) Lawrence, who introduces himself as an engineer interested in the efficient use of telephone cables, on the basis that the limited bandwidth of transatlantic cables could carry more calls if signals representing the basic

17. Singer to Kenneth Adam, «Eye on Research: Planning, Preparations and Policy Considerations», 17 October 1958, T14/1503.

18. *Eye on Research:* The Six Parameters of P.A.T.: http://vimeo.com/26005634

19. Strevens is not named in the broadcast, but the details are in the programme file T14/1,496/5.

components of speech were to be conveyed rather than the speech signal itself.[20] He explains that he had turned to the expertise of the Edinburgh phonetics department after his first attempt to build a 'PAT' in 1952. A vision cut takes the viewer to the head of department David Abercrombie (1909-1992) in a mock-up of his office (denoted by the bookshelves behind)[21], who explains – more fluently, but still with notes – his department's academic study of speech in a distinction he draws with Lawrence's interest in practical application. The phonetics lecturer Peter Ladefoged (1925-2006) then delivers a fluent twelve minute lecture demonstration with the assistance of a woman identified only as 'Miss Criper', using several pieces of apparatus in a cramped laboratory, of the selected components of speech: loudness, pitch, the 'noise sounds' of consonants, and three sets of overtones associated with different vowel sounds. In the next sequence, the machine is made to re-create the same parameters, in an explanation presented by an unnamed researcher, and their combined operation to synthesize speech is demonstrated by a moving model made by Alfred Wurmser. In the course of the explanation, 'Mr Anthony', the technician who constructed the machine, is named, and they seek to make PAT 'sing', with mixed results. The programme cuts to Lawrence, who invites viewers to send in their interpretations of six words spoken by the machine. Finally, we cut to Abercrombie, who explains some of the limitations of the machine in reproducing the speech sounds of various languages, and a summary of some of the other work of the department.[22] He hands over to Baxter in London, who stresses the interest of the links between fundamental and applied research exemplified by the programme and by several others in the series.

In this particular issue, Baxter as reporter is relatively marginal, and the programme ends up exemplifying the contemporary judgement of Norman Swallow that 'science, more than any other subject-matter, needs the personal communication of the expert, making use of equipment and devices which are familiar to him in his professional life' (Swallow, 1966:148). More often, as in the issues on CERN, *The Particle Hunters* (24 February 1959) or *Smaller than Life?* (30 September 1958), Baxter's introduction and mediation are much more substantial components of the programme's style. It is worth briefly considering the opening sections of one of these examples to show how the series' authority was normally established.

In the CERN programme[23], after an aerial shot and a spoken introduction by Baxter, the titles read – as was usual, though not in the PAT programme – 'Raymond Baxter reports'. His voice, from a control room, continues the exposition, including a cutaway shot of one of the

20. This was a project funded by the Ministry of Supply within the Phonetics Department at Edinburgh University.

21. Alan Rees to N.I.C Glasgow, «Week 44 Eye on Research», 13 Oct 1958, T14/1,496/5.

22. For some historical background on this work, see Ladefoged (1997: 85-91).

23. *Eye on Research* on CERN. An excerpt is available at

http://www.bbc.co.uk/historyofthebbc/resources/horizon50/before- horizon

'atom smashers', until a vision cut shows him introducing the physicist Ernst Michaelis, who explains his work on analogy with a football match watched from a distance, and with the help of a television set, which is explained to be a kind of particle accelerator. The air of the discussion is semi-formal; Baxter wears a two-piece suit, whilst Michaelis has a V-neck pullover; both wear ties. Here again, it is worth drawing attention to the quality of the speech, which in Baxter's case is immaculate received pronunciation, and in Michaelis's case is delivered with a slight Germanic inflection. Baxter's role is to translate, simplify and restate, performing an air of calmness and unflappability as a foil to his interviewee's evident nervousness. After Michaelis's exposition of the accelerator, using a film can cut in two, and an agreement between the two men that it's 'like a game of billiards, but an 'Alice in Wonderland' game, Baxter recapitulates as the camera tracks-in to medium close up: 'Right then. In order to look into this "Alice in Wonderland World", as Dr Michaelis put it, the entry is the beam of accelerated particles. The more detail you wish to see, the greater the energy you have to create, the larger the circle which the particles have to describe in their magnetic field'. In other words, the authoritativeness of an issue of *Eye on Research* was established by a combination of factors: In visual terms, Outside Broadcast technique conveys an immediacy, with its repertoire of cameras moving in small spaces, vision cuts, announced insert films (in the CERN programme, after his recapitulation, Baxter explains 'last week I flew over to make a piece of film about the proton-synchrotron'; we can take a closer look at it now'). The knowledge and explanatory capabilities of selected scientist-interlocutors gives an impression of important work being interrupted to provide an explanation. Then the reporter's stock of techniques to link, translate and simplify ties all the other components together.

New Programming in the Sciences

Both *Look* and *Eye on Research* embodied influential approaches to how the sciences should be shown on television, and both became a point of reaction against which later programmes would differentiate themselves.

In formulating how science should be covered after *Eye on Research* was cancelled in 1962, Singer's success with this series – bolstered by three promotions – ensured that it was he who would be charged with developing the series that succeeded it, which emerged on the new second BBC channel in May 1964 as *Horizon*. As I have argued, the majority of its core production team had worked on *Eye on Research* and they knew that 'whatever the new programme would be, it could not be a live Outside Broadcast visit to laboratories to speak to scientists at the bench'.[24] In *Horizon*, the production team, under Singer, determined to make a programme that was focussed on the culture, ideas and personalities of science. They eschewed topicality and they rejected being didactic. As Gordon Rattray Taylor, its

24. This section draws closely on findings, and reiterates parts of: Boon (2014b: 1–35, 7).

editor in 1965, proposed: *Horizon* 'will buttonhole rather than lecture'; the programme would say 'It's rather interesting that…' rather than 'Tonight we are going to tell you about…' (Taylor, 1964). As a *person-centred* account of science – an élite branch of culture – it was interested in what kinds of people scientists are, and so a fair few of the early programmes were centred on particular scientific personalities, including Buckminster Fuller, Michael Faraday and Peter Medawar, or groups of scientists such as *The Tots and the Quots* dining club convened prewar by the primatologist Solly Zuckerman. The BBC archives show that *Horizon*'s picture of science derived internally in the BBC, from television itself, and not from any explicit non-televisual source. In particular it came from the producers' determination to emulate another programme, the arts magazine *Monitor*, which had been running since 1958, edited and presented by Huw Wheldon (Wyver, 2007: 27-31). For much of *Horizon*'s first three years, the producers also sought to reproduce the form of *Monitor* as well as its approach to its subject. That meant making it as a magazine programme, and according to the expectations of the day, that entailed having an anchorman to lend unity to the programme by linking the separate items that composed it, also on-screen making the adjustments to individual items necessary in a live programme (Swallow, 1966: 48-50, 62-65). Paul Fox, editor of the current affairs programme *Panorama*, explained one value of anchormen:

> the personal contact between the programme and its audience is vital, and I am equally sure that the best way to establish the proper kind of contact is by means of a visible personality, someone who has down the years become something of a family friend, a regular visitor to the sitting room, a man whose words are respected and whose very presence has become … a guarantee of integrity and common sense. (Quoted in Swallow, 1966: 63)

This is effectively the role played both Peter Scott on *Look* and by Raymond Baxter on *Eye on Research*, especially in his piece to camera at the end of the *PAT* programme, where he goes beyond the particularity of the episode to help the viewer situate what they have seen in terms of the relationship of pure to applied science.[25] It is likely that it was this friendly guiding authority of a regular presenter that the producers of *Horizon* sought in their attempts to find a scientist-anchorman. There is no evidence within the detailed archive of the programme's origins that Baxter was ever considered for this role on *Horizon*; the fact that he was chosen a year later for this role on *Tomorrows World*, a programme envisaged as a topical report rather than a considered look at the culture of science, tells us something about the kind of authority they hoped to lend *Horizon* by having a scientist as

25. This is a boundary within the Edinburgh phonetics department that the programme glosses over, and about which the Head of Department had expressed some concerns - see T14/1,496/5.

anchorman. As I have shown, the *Horizon* producers' attempts to find a scientist capable of filling such a role, including an unsuccessful pilot programme using the theoretical physicist Roger Blin-Stoyle as anchorman, failed, which was one of the determining factors in the style of the programme in its first year, leading producers to experiment with presenter-less programmes united by a single theme, such as 'structure and form', or 'science, toys and magic'. In the absence of a suitable anchorman, these programmes, including the first, 'The World of Buckminster Fuller' (2 May 1964), fell back on the documentary film convention of 'voice of god' narration. In the first programme it was Gordon Davies who provided the guiding voice, with its warm, received pronunciation tones.[26] These narrators' voices, in this era almost exclusively *men's* voices, and by definition from unseen speakers, jettisoned the requirements of the embodied on-camera performance of a Baxter, and instead the repertoire of techniques that assert the programme's authority is solely verbal; of reading aloud someone else's script with conviction, of vocal timing, nuance, and appropriate stress.

After a year, the team achieved their ambition of making *Horizon* as a magazine, and so needed a presenter, but despite continued searching for scientist anchormen, they turned to journalists – first the BBC science news science correspondent Colin Riach, then Christopher Chataway, who had previously been on *Panorama* – to fulfil the role. The magazine format lasted for over 18 months until, with a change of editor in 1966, it became a programme envisaged and produced on film, and on a single subject, sometimes including Chataway as presenter, most often as 'voice of god' narrator, sometimes moving between the two modes as if there was no difference for the producers.[27]

Producers at Bristol, working with BBC2 Controller David Attenborough, also took the opportunity of the arrival of the new channel to create new modes of natural history broadcasting, as Jean-Baptiste Gouyon has shown.[28] The first of these programmes, *Life (in the Animal World)*, was designed to build on public appreciation of natural history by 'examining in a serious and critical way new trends and ideas in zoology'[29]. Like *Horizon* in its 1965-7 form, it was a studio-based magazine programme featuring discussions with experts, in its case on animal behaviour and including generous use of insert films. Its presenter was Desmond Morris, ethologist and curator of mammals at London zoo, a scientist-anchorman, if you like. The two new BBC2 programmes were broadcast fortnightly in alternation, and this was envisaged by Attenborough as providing 'methodological and serious' cover-

26. The term 'received pronunciation' alludes to what was commonly considered to be the 'correct' form of speech, in contrast to regional accents and pronunciations. Martin Stollery shows that this term was already in use in the 1930s; see his helpful discussion: Stollery (2011: 161-167).

27. This is seen, for example in Peter Goodchild's *Horizon, The War of the Boffins* (12 September 1967), where Chataway is heard as narrator long before he appears on camera.

28. My account here rests on Gouyon (2014).

29. Attenborough to Solly Zuckerman, 8 June 1966, TVART3, quoted by Gouyon (2014).

age of the sciences. The implication is clear that *Look*, with its repertoire of naturalist amateur scientists was somehow not quite serious science television. From 1967, *Life* was succeeded by *The World About Us* which, like *Horizon* from this date, was made entirely on film, and in colour, departing from the studio-bound live format of both the earlier series (Boon & Gouyon, 2015).

Conclusions

The examples here of the first regular natural history and science programming on BBC television in the 1950s, and their successors on the new channel BBC2 from 1964 onwards, show the importance of genealogy in the representational forms used in science television. *Look* drew on decades of conventions in natural history filmmaking, whilst the producers of *Eye on Research* were busy reinforcing a new form of television, drawing only on recent precedent. Equally, by the mid 1960s, television had already grown up enough to have established several genealogies of programme-making style, with the successful model of *Monitor* in the arts, for example, being taken up and extended in the coverage of several subjects, including science (Boon, 2014a). The live model of *Eye on Research* may similarly be seen as being resurrected, up to a point, in *Tomorrow's World*.[30]

Three different formal televisual factors emerged from my analysis of the establishment of *Horizon:* whether to use presenters as opposed to 'voice of god' narration; whether to favour live techniques as opposed to making complete documentary programmes on film ahead of broadcast, and whether to favour a diverse magazine programme over a single-subject broadcast.[31] Television producers in the 1960s – not just in science television, but across all subject domains – were actively experimenting with these components of their new televisual language. As they became fluent, the confidence and authority of television was made concrete. Caught like a fly in amber, particular authoritative articulations of the sciences, different in natural history from the rest of the sciences, also became established. On both sides, the significance of differing modes of performance by those on-screen and off was crucial to the authority conveyed.

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30. *Tomorrow's World*. An excerpt is available at http://www.bbc.co.uk/archive/tomorrowsworld/8001.shtml

31. These 'three factors' structured the presentation I gave at the 7th European Spring School on History of Science and Popularization: "Science on Television" in 2013, but the material I presented there has now already been published in my *BJHS* article on the origins of *Horizon* (Boon, 2014b).

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CREATIVE STRATEGIES FOR SCIENTIFIC TV DOCUMENTARIES

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Abstract: *Documentary producers and filmmakers attempting to communicate science on television must overcome two barriers: first, the structural differences between the standards of scientific communication and those of audiovisual storytelling; and second, the fact that the scientific process is, simply put, quite hard to capture on film. In this article we analyze these barriers and describe successful strategies that practitioners have used over the years to overcome them.*

Keywords: *Science on television, documentary films, popularization, science communication, film techniques*

Resum: *Els cineastes i els productors de documentals que tracten de comunicar ciència a la televisió han de superar dues barreres: en primer lloc, les diferències estructurals entre els convenis de la comunicació científica i els de la narració audiovisual; i, en segon lloc, el fet que el procés científic és, simplement, molt difícil de capturar a la pantalla. En aquest article analitzem les barreres esmentades i descrivim les estratègies que els professionals han utilitzat al llarg dels anys per superar-les amb èxit.*

Paraules clau: *ciència a la televisió, documentals, divulgació, comunicació científica, tècniques cinematogràfiques*

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Three Logics of Communication

The basic source of information for any producer making a film on a scientific topic is, ultimately, a number of papers relating to the matter at hand.[2] Often the initial idea comes from a book or an article in a newspaper or a magazine, which will already have predigested some of these papers. But a good producer will read at least the most relevant papers related to the topic of the film.

The first hurdle that the producer needs to overcome derives from the fact that scientific papers are structured and written in a way (following a *logic*) that is as distant as it can possibly be from the logic of the medium for which the film is intended – that is, the logic of TV documentaries. Let's see what the main differences are. Scientific papers

a) are written reports of several thousand words.
b) target professional scientists.
c) are written in an aseptic language, precise and emotionless.
d) use a lot of data, acronyms and equations (high information density).
e) use graphics as proof of the assertion(s) being made (statistics, microphotography). The graphics mostly convey raw or primary data.
f) carry information allowing the replication of the experiments by other scientists wishing to confirm or to refute the author's findings.

The structure of a scientific paper is highly codified. It consists of a variation of a basic linear scheme that includes title, list of authors, authors' affiliations, abstract, precedents, processes and results, citations and methods. This standard has been refined over decades of scientific publishing and is actually compulsory if one wishes to see results or hypothesis published[3]. As a consequence, the universe of scientific journals is quite homogene-

2. A note on terminology: for the purposes of this article, the expressions "TV documentary", "documentary" and "film" mean an audiovisual work which

a) is created with the main purpose of being shown on a television channel, either generalist (such as the BBC or PBS) or specialized (such as Discovery or National Geographic). This does not preclude other ways of dissemination (Internet, DVD, VOD…).
b) runs usually between 30 to 60 minutes.
c) is a stand-alone narrative, either as a one-off or as part of a series; as opposed to a news item or a magazine segment, which are part of a larger entity.
d) aims for a long shelf life – in other words, is not directly influenced by the current events or news agenda, which might render its content obsolete in a matter of days or weeks.

The person(s) ultimately responsible for the creative task of making a scientific documentary are be referred to as "producer", "filmmaker" or "author", without distinction.

3. Anyone deviating from the standard will not be "heard" by the scientific community. This is one of the issues addressed in *The Man who unfolded a thousand hearts* (Dani Resines, 2007). This documentary tells the story of Paco Torrent Guasp, a

ous – very unlike the universe of television programming, in which TV documentaries exist.

Indeed, television offers a quite diverse and heterogeneous palette of programming, ranging from hard information (such as newscasts), to pure entertainment (such as music videos) including fiction, advertising, live events (sports) and many others. In this article we will argue that any programming offered on television can be located in a quadrangular, virtual "space" whose corners are occupied by 4 main "genres": news, fiction, entertainment and advertising (figure 1).

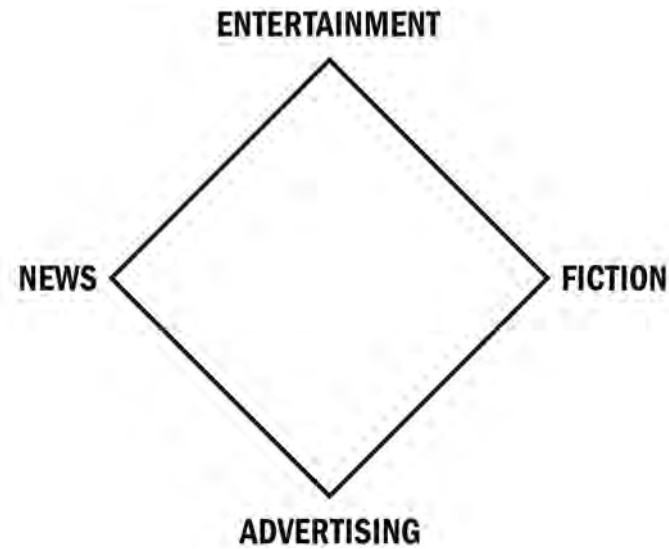

Figure 1.

Documentaries tend to sit in the News/Fiction axis[4] which has, in one end, the daily newscasts and the 24 hours news channels and, on the other end, series such as *Downton Abbey*, *Homeland* or *The big bang theory*, to name but a few current ones (figure 2). Current affairs shows – such as *Informe Semanal* (TVE), *Panorama* (BBC) or *60 Minutes* (CBS) – are a step removed from the News end, while films based on a true story (*The Monuments Men*, *The Wolf of Wall Street*, *Philomena* to mention but a few recent ones) are not pure fiction,

Spanish family doctor who in the 1980s solved the centuries old mystery of the heart's true anatomy, but whom nobody believed because he did not communicate his findings in the prescribed way. <http://vimeo.com/32674446>.

4. For the sake of clarity I am oversimplifying the issue – there is a degree of entertainment value in news and documentaries; and sometimes advertising (or propaganda) as well.

although they sit quite close to it. Documentaries occupy a fuzzy area in the center of the axis, because they juggle two logics: the logic of news and the logic of storytelling.

Figure 2.

Printed news

a) are written reports of several thousand words, although usually shorter than scientific papers
b) are targeted at the general public
c) are written in common language
d) use data and acronyms but no equations the information density is lower than in scientific papers
e) use graphics as illustrations of the concepts being discussed. The graphics are usually elaborate simplifications of the processes described in the scientific papers.

This is also mostly true for TV news, because often the weight of the information is carried by the reporter's narration, while the image track is just an illustration, generic or specific, of what's being reported.[5]

The "canonic" logic of news is, in essence, to pack as much information (facts) as possible in the given space or time. It uses the rule of the 5 Ws (an information, to be complete, must provide the answers to these questions: Who, What, When, Where, Why –some authors add "How") and follows the structure of the inverted pyramid (figure 3): the most relevant information always goes at the beginning of the news item and details are added further down, so the reader can leave the story at any point and will still have gotten the gist of it.[6]

5. Watch a newscast with the sound off: you will "get" the general topic being dealt with (the war in Syria, a meeting of the EU heads of State, the stock market) but you will not get the details (how many casualties, what is the outcome of the meeting, a new regulation is planned) because those are carried by the voiceover – or by captions, therefore in "print".

6. In the era of Internet and social media, printed news (the actual newspaper) has changed a lot and provides more analysis and context. But the basic tenet of journalism is still to offer new, timely information to the reader/viewer/customer.

Figure 3. The inverted pyramid

Although scientific documentaries are not news items, they share some of their logic, in the sense that docs, too, *must carry facts*. However, they need to sustain the attention of the viewer for a longer period of time – docs last 30 to 60 minutes, while a news item runs usually between a minute and a half and three minutes. And there's a reason for the brevity of news items on TV: the medium is very ill-suited to convey facts, because the mere piling up of fact after fact quickly saturates the viewer who, simply, disconnects.

So, how can producers convey the information and still keep the audience until the end of the show? By using the tools of storytelling. The problem is that the logic of storytelling is completely different from that of science papers or news reporting. It is the logic of *fiction*, be it a Greek tragedy, a Shakespearean comedy or the latest blockbuster action film. In spite of all their differences, they share an underlying structure that can be summarized as follows (figure 4): There is a world at peace, in equilibrium, where people go happily about their lives. Suddenly, something happens (*the inciting incident*) that breaks the balance and creates a tension, a conflict. The Protagonist (*the hero*) tries to solve the problem and fights the Antagonist (*the bad guy*). But things, instead of easing out, become more and more complicated and the dramatic tension rises until there is a final showdown between Protagonist and Antagonist (*the climax*) in which – usually – the hero wins over the bad guy. After that, the tension releases and equilibrium is restored. But something else has happened: the hero has changed along the way; (s)he has *evolved* as a character.

In other words, storytelling is about *emotional journeys unfolding over time*. As humans, we are brain wired to appreciate this sort of narrative, which provides an emotional roller-coaster from the comfort (and safety) of the living room, the cinema or your parent's lap. That's why children like to be told (or to watch) the same story again and again – they want to feel those emotions over and over.

Not only is the structure of storytelling quite different from that of scientific papers or news reports: its building blocks are of a totally different nature. Where papers and news are based on facts, stories are built from actions that their characters undertake (in the

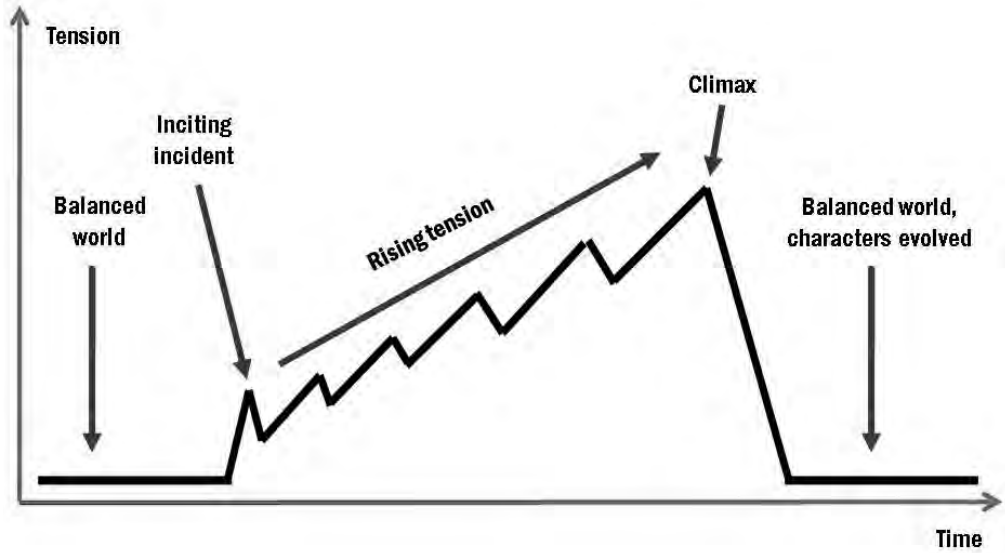

Figure 4. The classic structure of stories

Hollywood credo, a character reveals his personality through his actions, not through his words).

Film (and TV) is a very good medium for storytelling, because it is very well suited to convey emotions through the actions and words of the characters on the screen. Therefore, any science documentary producer finds his or herself in a bind: the nature of the message to convey is about facts (and abstract ideas) which work very poorly on the medium – which works best with actions and emotions. To make things worse, the scientific process is opaque to the camera.

Why science is hard to film

Documentary films are built with a combination of elements:

- Original shooting (actuality, interviews, reenactments)
- Archival footage and still images
- Scientific imagery produced by scientific instruments – telescope, microscope…
- Graphics and animations
- Narration
- Music
- Sound effects

In cinematic terms, the most powerful of these elements is, by far, actuality (the events happening in front of the camera as it is filming) –as long as what's happening in front of the

camera involves the interaction of one or more characters between themselves or with the environment.[7]

Without any narration or interview, just with actuality (and editing) you have surely got most of what was going on in the scene. A group of people are in the desert, where a car has broken down (*the wheels don't turn, the doors don't close!*). It is a diverse group, they speak English and other languages. The owners of the car are three youngsters we see on camera and a fourth one behind it, who is filming. They do not know much about car mechanics and they just cannot believe their old Citroën can be repaired *then and there*. The others in the group, though, who clearly know about cars, are totally convinced it is feasible – and set out to actually do it. The method they use is most unconventional, but they succeed in repairing the car while the youngsters look on flabbergasted. One of the members of the group, whose face is covered by a scarf, acts as a sort of leader. We do not see his face at all, but we" get" his personality: he has a very British sense of humor and an unshakable faith in the power of a cup of tea.

The only things that you do not get from that sequence are factual details: Who are they, where are they and why? They are somewhere in the Sahara desert; they take part in the Plymouth-Banjul Challenge, a sort of anti-rally in which participants drive old cars from the UK to Gambia, where they are auctioned for charity; the youngsters are Catalan, and the rest of the group is a mix of Brits and Americans. These factual details, though, are pretty irrelevant for our understanding and enjoyment of the excerpt – which, by the way, follows closely the pattern of storytelling structure we have seen in figure 4. There is an incident (the car broke down); there is a protagonist (the guy with the scarf) and an antagonist (the lack of resources); there are unforeseen complications (the battery leaks and they have to start over again) and a climax (the car runs again); and the characters are transformed (the youngsters, who are secondary protagonists, learn that with determination, good humor and a cup of tea, no problem is insurmountable).

This sequence is very rich in action and interaction, but actuality works also in subtler circumstances. Take, for instance, one of many YouTube videos where we see a young kid, deaf, who hears for the first time thanks to a cochlear implant[8]. The expression on his face says it all – here, as the saying goes, an image is worth a thousand words.

These two examples show that the filming of actuality is very well suited to capture processes, interactions evolving over time. So it should also work to capture the scientific process –but it actually does not, due to the specific characteristics of the way science is carried out nowadays. In essence, the work of a scientist consists of

7. <http://vimeo.com/106685779> *This is not the Dakar*, by Pepe Rodríguez and Sheila Aguado (2007), produced by Media 3.14.

8. <https://www.youtube.com/watch?v=-GA9gEh1fLs>

a) Observing the world and finding an interesting set of data
b) Thinking about that data set
c) Coming up with a hypothesis
d) Devising and carrying out experiments to test the hypothesis
e) Thinking about the results of the test, coming to conclusions
f) Publishing the conclusions

The first step already poses a problem because *the tools that scientists use to observe the world are mostly opaque to the viewer*, be it a layperson or another scientist. Step into any lab and you will be surrounded by computers and by machines and devices which operate on the black box principle: something goes on inside them that we cannot see directly; the display is usually mediated by yet another computer, where results will appear as numbers or abstract graphics meaningful only to the initiated. If it is a biology lab, there will be microscopes, Petri dishes, shakers, centrifuges, maybe containers with liquid nitrogen, you name it. The people in the lab will be busy using all these tools and of course it is possible to film them, but that actuality will reveal practically nothing about what they are doing because the level of visual interaction is very low and the camera cannot see directly the effects of what the scientist is doing.[9] The visual appeal of molecular gastronomy – where cooking and science meet – is precisely that we can see what is happening to the food as it is being processed. If Ferran Adrià's miracles happened inside a closed pressure cooker, the discipline he founded would have a much lesser appeal to the general public, even if the results were the same.

The opacity problem not only appears when observing the world but also when carrying out the experiments[10], and for the same reasons. It is important to note here that the fact that an experiment is "legible" does not mean it becomes immediately meaningful to the lay observer. Science museums all around the world offer experiments and installations to their public which convey or illustrate basic scientific facts (maybe the most classic is Foucault's pendulum "showing" the rotation of the earth) but they must provide the relevant explanations as well for the public to take the lesson home.

Every generalization has its exceptions, and there are indeed branches of science which provide "good", meaningful actuality because they are not opaque to the camera. In general, sciences which focus on the behavior of humans or animals suffer a lesser degree of opacity, precisely because they observe interactions between the subjects and the environment. In

9. That is why TV shows that offer science as entertainment always select flashy experiments whose results are very visible and spectacular, be it explosions, billowing clouds of smoke or sudden changes in shape or structure of the materials.

10. This was not always the case. Until the nineteenth century, experiments were quite directly "legible" because scientists were still working, so to speak, at a macroscopic level. Only when they started working at the microscopic and atomic level did the tools become opaque to the outside observer.

the 1970s Michael Kirk-Smith and David Booth, researchers at the University of Birmingham, sprayed a male pheromone onto a chair in a dentist's office and then observed the reactions of men and women who were asked to enter the room. Women tended to sit on or close to the chair, while men sat at a distance away from it – and none sat on the chair itself. The visual recording of the experiment is perfectly legible and, once the viewer is told what's going on, can be even entertaining, as it is possible to turn the experiment into a guessing game: in which chair will the subject sit?[11]

However, most science today is opaque and, thus, filming scientists while observing nature or carrying out an experiment usually lends not very "good" actuality. What about that other very important part of their work – thinking? Here, the camera is largely useless: film does not capture the *thoughts* of a subject, only their facial expressions and body language. The act of (purposefully) thinking has been associated with stillness, as in Rodin's famous sculpture *The Thinker.* Indeed, there are scientists who like to sit in nearly absolute isolation when pondering a problem but there are also many others who go for walks or do any other sort of activity while their mind is working in "background" mode. But if we were to film them at those moments, the camera would just capture the image of a person walking, or gardening, or playing the piano, or riding a bike… We would still not *see* their thoughts.

At this point a reader might say: "The camera does not capture thoughts, but it certainly captures words. Another part of a scientist's work is discussing findings and results with colleagues while trying to find the explanation to the results, or while devising the experiments. That is a conversation between persons, and should work as actuality". Indeed, a conversation can have a lot of interaction and can be very engaging, thus providing good actuality… if the language is accessible to the viewer. And most often, when scientists are discussing a scientific topic because they are trying to reach some sort of conclusion (that is, when the conversation is relevant to them, as opposed to when they are playing for the camera and "explaining" the issue) they'll use a highly specialized language, full of specific terms, which can only be understood by a viewer trained in the same domain. A layperson is very likely going to be shut off from the conversation for lack of the required knowledge.

This happened in *The Dali Dimension*[12] (Susi Marquès, Eli Pons, Joan Úbeda, 2004), a film I produced which retraces the huge influence that science had in the life and work of Salvador Dalí – for him it was a source of inspiration and visual motifs which can be found up until his very last painting. The film's narrative structure is based on footage from a three-day seminar which took place in Dalí's museum in Figueres in 1985, where top-ranking

11. The film *La biochimie du coup de foudre* (Thierry Nolin, 1997, produced by Arte and Morgana Films), includes a visual record of the experiment, although it is not clear whether it's the actual experiment by Kirk-Smith and Booth or a reenactment of it.

12. <http://dalidimension.com/eng/synopsis.htm>

scientists met to discuss the role of chance in nature. It was a high-end physics debate which the painter, already very ill, followed via closed-circuit TV from a room in the building. Dalí was an avid reader of scientific literature and witnesses had told us that for him, listening to researchers was akin to enjoying music. Our initial intention was to include in the film a few segments of the actual talks and debates and we had a researcher listen to the full 18-hour recording of the proceedings to locate suitable excerpts. There was not a single passage that a common viewer would have understood –those were researchers addressing their peers and therefore not making any attempt to simplify the issues being discussed.[13] (We resorted to using music instead of the scientist's words). The only moment we could include was a confrontation between Ilya Prigogine (Nobel Prize in Chemistry in 1977) and René Thom (mathematician, winner of the Fields Medal in 1958) who clashed over their views on thermodynamics. For a few moments, they addressed each other in words (and body language) that anyone could understand – and that exchange gave rise to an anecdote that was evoked by some of the participants.

We have just seen three main reasons that make science hard to film as a process (in other words, that make science a poor provider of actuality[14]): the opacity of the tools, the fact that no camera can see the thoughts of a subject, and the barrier created by specialized scientific language. There is yet another reason, which has do to with time. As it happens, most scientific work takes a lot of time; planning, preparing, executing and validating an experiment is a long process.[15] In addition, nobody knows beforehand if the results will be successful or a failure, if at the end there will be a breakthrough or a disappointment.

These four reasons combined explain why the scientific process does not lend itself to be told on TV in the present time, in "making of" mode – as opposed to, say, the process that an athlete undergoes in preparing for a competition. The viewer can *see* the effect produced by repetitive training or by the introduction of a new technique or piece of equipment: the performance gets better and better, increasing the chances for the athlete to win the competition; which is to say, increasing the suspense for the viewer: will (s)he succeed? The same is valid for the creation of a theater play or choreography from first reading to opening night: we can witness the director's vision gradually taking shape through the movement, gestures and words of the performers. On the contrary, science on TV consists usually of the presentation of known facts (the laws of physics, a new view of the molecular mechanism of cancer), which were discovered as a result of a research process already completed –

13. The problem of language as a barrier is not exclusive of scientists, though: think of a conversation between car mechanics, computer experts or wine tasters – the same situation arises and the lingo of the trade leaves out the lay person.

14. Contrary to engineering and, by extension, technology, which consist in building something out of parts. That's a very visible process, be it building the world's tallest skyscraper or the smallest electronic device.

15. Fiction series with a scientific touch, such as *CSI*, have been criticized precisely for the liberties they take with the time involved in carrying out tasks such as DNA sequencing or other complex tests.

therefore as something that happened in the past and which is told to us from the present. (Or just as the presentation of facts, without any reference to how they were discovered). That is why there are no true, actual "eureka" moments in any scientific film: the camera is never there when the researcher has the epiphany that brings the key to the discovery. Whenever we see it, it is either a remembrance (the scientist evokes it in an interview[16]) or a reenactment.

The environment in which science documentaries are produced also plays a role in this state of affairs. TV executives have a strong aversion to incertitude and, given that time equals money, they very rarely – if ever – consider following an experiment or an investigation as a work in progress from beginning to end.

As a result of the inherent difficulties that science creates for filmmakers and the ecology of the TV environment, practically all scientific films are issue-driven and not character-driven – a film based on characters is necessarily based on actuality. With this in mind it is easy to understand the impact created by *Particle Fever*[17] (David Kaplan and Mark Levinson, 2013), a feature-length cinema documentary on the discovery of the Higgs boson at CERN which is an amazing exception to the rule – a film on particle physics which is entirely based on characters and their interactions, which the authors followed on and off for years. In my view, this film exists precisely because its financing did not come from the usual sources that pay for science on TV: broadcasters and foundations. Instead, it was mostly funded by private investors. Many of them were former physicists turned hedge fund managers in Wall Street who had made fortunes applying their mathematical skills to a different set of problems.

Creative strategies

The task facing any producer of scientific documentaries is how to convey the required data with a medium which is so ill-suited to this task, as we have seen before. The tension between the two extremes of the continuum "delivery of information-storytelling" (news-fiction in Figure 1) is acutely felt once the research phase is over and the time comes to write a narrative treatment, a script for the film. In over 30 years of experience, I have come to realize that there is an inversely proportional relation between the amount of data that a film can convey and its capacity to be told as a story. In other words: if one pushes the film from the "news/information" side towards the "fiction/storytelling" side, the film becomes more

16. Such a remembrance can be a powerful television moment. In the opening sequence of *Horizon: Fermat's Last Theorem* (written and produced by John Lynch, directed by Simon Singh, 1996, BBC) the mathematician Andrew Wiles, who had solved a problem that baffled minds for three centuries, sits at his desk reminiscing the moment when he "saw" the solution to the proof. Suddenly, his voice cracks as he says "Nothing I will do again will ever…" He's just realized that he has peaked, and that from now onwards his career will be in the shadow of the amazing work he did in the previous years.

17. <http://particlefever.com/>

satisfactory as a film, more "organic" and round as a story but, at the same time, there is less and less room for it to convey information (data).

At this stage, when the film is just text typed on a computer screen, another concern is that it must be able to capture and sustain an audience in an environment of hundreds of linear channels and a drowning number of online options, all competing for the attention of the viewer/user/consumer. Of course, science and knowledge in general have an intellectual appeal which can be quite powerful – but to count solely on it as a tool to engage the viewer may be over-optimistic and one may fall in the trap of preaching to the converted.

Over time, producers have used a number of strategies that seem to be efficient in reaching the elusive goal of being entertaining yet at the same time informative. The following are a few examples of these strategies, culled from my own experience and from some of the films I have seen throughout my career which have created on me an impression strong enough as to remember them years later.[18] This is a personal selection, there may be other recognizable strategies that I have not come across, or that I have not recognized, or that just did not interest me enough and therefore did not leave a lasting memory in my mind.

Make it relevant for the viewer

If viewers feel that the information being conveyed by the film is directly relevant to them, they are more likely to stay with it than if they feel the subject matter to be remote. The idea is to present the practical outcomes (present or future) of the science being discussed, and how they will affect every viewer as an individual and/or society as a whole. This approach works especially well with films focusing on medical, biological, environmental or engineering stories, because in principle it is possible to talk about practical outcomes. Thus, in a film focusing on the latest advances in the battle against cancer, or Alzheimer, it makes sense to introduce a patient whom we follow as he is using a new treatment over a few weeks. His evolution over this period will provide a storyline (beginning, middle, end) on which to graft the parts of the film dealing more directly with the science behind the treatment. It is harder to bring it close to the viewer if the films deals, for instance, with basic physics.

Anthropomorphize

Attributing human qualities to non-human entities has long been a way to bring a story closer to the reader. In certain kinds of film, this strategy also works. It is used quite regularly in wildlife films, where feelings are attributed to animals when discussing their behaviors. It also was quite popular in the 1950s in educational animated films such as *A is for Atom*[19] (1952) or *The light of your life*[20] (1949), film produced by General Electric.

18. When possible, I have obtained permission from the producers to include excerpts of the films as part of this article.
19. <https://www.youtube.com/watch?v=34tKkET_TFE>
20. <https://www.youtube.com/watch?v=FyEQnv1DYEo>

Build something

Any film is a linear narrative that is deployed over its running time. Ideally, something should happen during that time that carries the narrative forward to a satisfying conclusion. On the other hand, the information to be conveyed in a scientific film most often is not structured as a function of time. How to solve the conundrum? Imagine that you want to make a film about the science of metallurgy – or that you are *commissioned* to make such a film. On the face of it, it may sound like a flat proposition, without any traction to carry the film. But what if you followed the actual making of a metal artifact? That surely has a beginning (mining the ore), a middle (smelting the iron, shaping it) and an end (the finished product). So, one could follow the process – in which we can see the interactions, as it is a technological process- and now and then insert a short segment about the hard science of metals. Sounds like a good idea. So, what do we build: a teapot? Well, *that* does not have a lot of appeal, does it?

The producers of NOVA, the flagship science show on the US public television system, settled for a metallic object with a little bit more mystery and attraction. Secrets of the Samurai Sword[21] (produced by Doug Hamilton for NOVA; 2007) follows fifteen traditional Japanese craftsmen over nearly six months as they create a sword "capable of slicing through a row of warriors at one swoop". The choice is wise, not only because of the elaborate method of forging and the intricacies of metallurgy that can be explained throughout the process. The film also draws on the popular appeal of the katana, the samurais and, in general, of the Japanese classic traditions – which helps to draw viewers in and, possibly, to have them stay until the end.

Looking at "the science of X" where X is anything with popular appeal (the Titanic, sex, casinos, wine… you name it) is also a well-established strategy to sweeten the pill for the viewer, even if there is no construction involved (James Cameron nearly rebuilt the Titanic for his film, but he was not into science).

Use analogies and metaphors

Very often we resort to analogies and metaphors when trying to explain a scientific concept in a conversation or in writing. The same can be done with film, as shown by these two examples.

While raising funds for *The Dali Dimension* I approached commissioning editors from several broadcasters, both from the fields of the arts and the science, as the film actually sits between the two. I quickly realized that the people from the arts were a little bit anxious on hearing that the film would deal with particle physics, relativity or higher dimensions mathematics – they were afraid that the viewer would not understand these matters because they themselves were a little bit lost while talking to me. One particularly difficult hurdle in-

21. <http://www.pbs.org/wgbh/nova/ancient/secrets-samurai-sword.html>

volved the painting *Corpus Hipercubus*[22] (1954) where Dalí was consciously quoting a four-dimensional object (a hypercube) in connection to the divine nature of Jesus Christ. To make them understand the concept of a four-dimensional cube, I carried with me a bit of cardboard in the shape of a cross made out of six squares which I showed to them saying: "See, this is a two dimensional object, six flat squares. But if I fold it, it becomes a three-dimensional object, a cube. Now imagine that you have eight cubes forming a shape similar to a cross. In a world of four dimensions, which we cannot actually imagine but that we can intellectually conceive, you could fold those cubes into a four-dimensional cube – a hypercube. Well, Dalí painted eight cubes forming a cross –an unfolded hypercube". The fact that they saw me fold the cardboard as I was talking made them understand the concept and overcome their worries. It was such an effective tool that it found its way into the film.[23]

One of the best examples of the power of visual analogies and metaphors in a science film is, undoubtedly, *Death by Design* (directed by Peter Friedman and Jean-François Brunet, produced by Emmanuel Laurent, 1995). The film's subject matter is apoptosis, the mechanism of programmed cell death, which is fundamental to life. As usual, the filmmakers resort to using interviews and scientific imagery, in this case micro cinematography of all kind of cells doing all kind of cellular things. But the stroke of genius that turns a quite stale subject matter into a fascinating creative work is the use of ancient archival footage to build and sustain the metaphor of "cells as a society of individuals". The interviewees, all top-notch scientists in their field, gladly accept to use this comparison: an organism is like a society made of individuals, each cell is an individual in that society. And the filmmakers combine their statements[24] with the scientific imagery and with a carefully researched selection of bits of newsreels, slapstick comedies, even excerpts from Busby Berkeley films[25]. The combination of all these elements, plus a very carefully selected music score, creates a seductive atmosphere that captivates the viewer. Already in the opening credits[26] the analogy is made – the film begins with a montage of the trailer from the '50s science fiction film *It Came From Outer Space* which sets the tone – serious, meaningful content served in a highly unusual way.

22. <http://www.salvador-dali.org/cataleg_raonat/resized_imatge.php?obra=681&imatge=1>

23. <http://vimeo.com/107064660>

24. Interviewing a scientist can be a very tough task because it is vital to have them talk in a way that will be understandable for an average viewer (a filmmaker should never overestimate the amount of information viewers have, nor underestimate their intelligence). Many scientists are just unable or unwilling to do that, usually because they fear that if they "dumb down" their discourse too much they will be criticized by other scientists. As a general rule, the scientists who speak better for the camera are those who have nothing to prove to themselves or to the world, because they have already succeeded (or because they do not care about outside criticism). And those are usually the ones at the top of their field.

25. <http://vimeo.com/107078904>

26. <http://vimeo.com/107078905>

Being literal

Instead of using analogies, sometimes producers resort to being actually literal, to putting on the screen exactly what the subject matter proposition is about. In 2010, the Japanese public broadcaster (NHK) and Al Jazeera Children's Channel introduced a series called *Discover Science*[27], aimed at a children's audience, aged between 7 and 11. In each episode, which lasts about 15 minutes, an experiment is carried out to demonstrate a law of nature. The twist is that the experiments are made on a large (actual) scale, and the program forfeits the use of any computer graphics. The episode called *Let's see the speed of sound*[28] is a very good example of the strategy. The aim of the program is to show that sound travels at about 340 meters per second. To do so, the producers organize a line of 86 people that covers 1,700 meters, each one holding a flag (the experiment is shot at a pier in a harbor). At one end of the line, a master of ceremonies produces several different sounds (with a horn, a trumpet, a pair of cymbals…). The participants, lined facing away from the MC, raise their flag when they hear the sound. The result is very effective because, when the sound is produced, the raising of the flags actually *makes visible* the progress of the sound wave along the pier[29]. The producers keep track of how long it takes for the last flag to be raised; then a simple division is made (space/time) and they come up with the figure of the actual speed of sound in that precise event and location.

The Plane Crash[30] (2012), another remarkable life-size experiment, was undertaken in 2012 by Dragonfly Film and TV, Discovery Channel, Channel 4 (UK) and ProSieben (Germany) for a 90-minute special in which a Boeing 727 passenger jet was crashed on purpose at the Sonora desert in the north of Mexico. The plane was fitted with cameras and sensors, and filled with state-of-the-art crash test dummies. The aim of the project was to provide actual data to a team of scientists in order to study the crashworthiness of the aircraft's airframe and cabin, examine the impact of crashes on the human body, and look for possible means of increasing passenger survivability. By crashing the plane, the producers also aimed to answer key questions - such as whether sitting at the front or the rear of the aircraft, wearing a seat belt, and using the brace position - can make the difference between life and death.

In that particular case the plane crashed nose first and the passengers in the front rows would have most likely died, while those in the back section would have escaped practically uninjured. However, in another accident configuration the results could have been oppo-

27. <http://www.onscreenasia.com/article/swr-ur-ebs-and-astro-join-nhk-ned-jcc-s-discover-science/7668>

28. <www.br-online.de/jugend/izi/english/research/discuss_quality/discusses_quality_2010/_7-11%20non-%20fiction/Speed%20of%20Sound.pdf>

29. <https://www.youtube.com/watch?v=NPPgQcFUrXk>

30. <http://www.channel4.com/programmes/the-plane-crash>

site. This prompted some reviewers[31] to comment that the data gathered in the experiment was essentially a confirmation of what was already known (wearing a seat belt is safe; the brace position avoids injuries to the head).

Literality is also at the base of the concept for *The Human Footprint*[32] (2007), a film by Touch Productions for Channel 4 and National Geographic. The film aims at raising the viewer's awareness about the environmental cost that human action has on the planet. To do so, the filmmakers show several examples of the materials consumed over a lifetime by an average American (or Briton), embodied by a couple of lovely kids whom we see growing up into adulthood and old age[33]. The trick is that they do it by showing on camera the actual amount of that material – they line over 7,000 bricks of milk in front of the kid's house; they have the boy and the girl, now teenagers, swimming in a pool filled with all the gallons of beer an average person consumes over a lifetime or "bathing" in a bathtub filled with all 500-plus kilograms of red beans eaten with all those English breakfasts; they show the host wandering in a maze made with the thousands of newspapers read by an average US citizen; and so on. The trick works its magic on the viewer because it draws on the "wow" factor – a statistic is a cold number which may or not impress us; *seeing* the statistic embodied in actual size certainly catches the attention (although, some reviewers[34] thought, it wears out after a while).

Change of scale

The same effect of amazement that can be generated by being literal can be achieved by changing the scale of a given experiment or process. Usually this entails reducing the scale to make a microscopic process visible to the naked eye, but the reverse (enlarging the scale) can be useful to deal with astronomic distances, for instance.

One of the most creative examples of this strategy is *The Great Sperm Race*[35] (directed by Julian Jones, produced by Dan Chambers and Justine Kershaw; Blink Films and Cream Productions for Channel 4, National Geographic and Discovery Canada; 2009). The film tells a well-trodden story: human conception, namely the short period that elapses between intercourse and ejaculation until a sperm reaches and impregnates the egg. But the way the story is told makes the difference: to start with, it is framed as "natures' harshest competition", a race with 250 million participants but only one winner, with deadly traps waiting at every step. The film's narration focuses on all the perils and dangers a sperm must face in order to have a chance to be the winner and thus carry its genetic load onto a new genera-

31. <http://www.independent.co.uk/arts-entertainment/tv/reviews/last-nights-viewing-the-plane-crash-channel-4homefront-itv1-8208003.html>

32. <http://channel.nationalgeographic.com/channel/human-footprint/consumption-interactive.html>

33. Oftentimes a film will use a combination of strategies, in this case, literality and closeness to the viewer.

34. <http://www.nytimes.com/2008/04/12/arts/television/12foot.html?_r=1&>

35. <http://www.julianjonesdirector.co.uk/thegreatspermrace.html>

tion. On top of that, the producers change the scale and, in a wink and a nod to a Woody Allen classic[36], they have the millions of sperm represented by thousands of white-clad men and women who run like mad trough hills and valleys which represent the vagina and the uterus. This representational device is intercut with dramatized scenes with the couple involved, and segments of hard science with the usual combination of interviews with scientists and actuality shootings at labs and research centers.

Rebuild the past

As discussed previously, many scientific films tend to present known facts which were discovered as a result of a research process already closed, in other words as a story from the past, be it distant or recent.

A classical approach is the *biopic*, the biography of a scientist and his discoveries. This provides a narrative frame, usually chronological, which weaves together the events in the life of the scientist with the progress (and stalls) of his research until reaching the result for which he became famous –or was ignored, this being the reason for making the film in the first place.

For a biopic to succeed, though, two conditions must be met: the character has to be interesting (possibly with some sort of conflict in his life), and his discovery must be of a certain consequence. If the scientist is a bland, grey character who did not produce anything of relevance, there will be no way to make an interesting, engaging film out of his life story (except maybe a memento for the family).

There are many creative choices for a biopic, ranging from the straightforward documentary to the work of fiction, including feature films aimed at the cinema screen. British actor Benedict Cumberbatch has portrayed two of the best minds of the twentieth century, Alan Turing (*The Imitation Game*[37], directed by Morten Tyldum; The Weinstein Company, 2014) and Stephen Hawking (*Hawking*[38], directed by Philip Martin; BBC, 2004). The earlier is a "based on a true story" film (meaning more than a few liberties have been taken with the facts) while the latter is a TV movie produced as a collaboration between the BBC's Drama department and *Horizon*[39], the corporation's flagship science documentary strand –which, in principle, should guarantee that the facts have been better preserved than with Turing's film.

A different take on the reconstruction of the past is to chart the *timeline of a discovery*, which allows touching on the contributions of several researchers or scientists. *E=mc*^{2} *Ein-*

36. One of the sketches in *Everything you ever wanted to know about sex but were afraid to ask* (Woody Allen, 1972) works on the same scale-change device but for comic effect. The film actually focuses on the workings of the brain and the organism in general during a seduction process. The Great Sperm Race takes up from where Allen's film finishes – ejaculation.

37. <https://www.youtube.com/watch?v=S5CjKEFb-sM>

38. <http://www.bbc.co.uk/sn/tvradio/programmes/hawking/>

39. <http://www.bbc.co.uk/programmes/b006mgxf>

stein's Big Idea[40] (directed by Gary Johnstone; Darlow Smithson Productions for WGBH, Channel 4, Arte/France and NDR; 2005), a docudrama based on a book by David Bodanis, retraces the biography of the equation – that is how the terms of the equation (energy, mass, the speed of light) came to be discovered and understood, and how Einstein brought them together in his most famous equation. Besides Einstein and his contemporaries, the film includes characters such as Lavoisier, Faraday or Maxwell in a sweeping narrative that covers a great deal of the history of physics.

Director David Dugan chose a similar approach for *Absolute Zero*[41] (Windfall Films and Meridian Productions for BBC4, NOVA, ARTE; 2007), based on a book by Tom Shachtman. The story of the quest to reach the lowest temperature possible (zero Kelvin degrees) provides insight into the physics of matter and into the lives of some of the researchers who made the greatest advances in the field.

There's something about species[42] (directed by Denis Van Waerebeke; Ex Nihilo for ARTE, France 5, NHK; 2009) charts the story of evolution by retracing how scientists have tried to make sense of the diversity of life by providing a classification – in fact, telling the story (and meaning) of taxonomy.

A twist on the idea of the timeline consists in charting the contribution that an instrument or a technique has had on a given field of research. The central character of *Superfly*[43] (directed by Philip Smith, Oxford Film & TV, 2002) is *Drosophila melanogaster*, the fruit fly. Over the last hundred years, this small insect has been used to unlock many of the secrets of genetics (60 percent of our genes are the same as the fly's) because its very fast life cycle makes it possible to breed many generations over a short period of time and to find natural mutations. Using specialist photography and 3D animation the film retraces the main discoveries made through experiments involving the fly and portrays some of the current experiments being carried out, which include gay, drunk and violent flies, as well as mutants high on crack cocaine, all lovingly raised by a slightly obsessed breed of scientists past and present.

Conclusion

There are objective reasons that make science a particularly difficult subject matter for films. Directors and producers have devised strategies to overcome this problem by looking at ways to present science as a story, because scientific laws are abstract, but their discovery is the result of a quest for understanding whose central characters, the researchers, are flesh and blood human beings.

40. <http://www.pbs.org/wgbh/nova/physics/einstein-big-idea.html>
41. <http://www.pbs.org/wgbh/nova/zero/credits.html>
42. <http://www.cultureunplugged.com/play/6950/There-Is-Something-About-Species>
43. <http://www.bbc.co.uk/programmes/b0074n9h>

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CURRENT STATE AND CHALLENGES OF SCIENCE IN TODAY'S TV: A LOOK AT THE INTERPLAY BETWEEN SUPPLY AND DEMAND ON EUROPEAN MEDIA MARKETS

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Abstract: *This study assesses the current state of science in TV and its future challenges. The assessments are based in substantial parts on a couple of comparative empirical media studies published in the last decade. The focus of these studies was either on the production of science contents in European TV, or on the reception of these contents by European Audiences. This paper integrates both perspectives into a comprehensive picture in order to unlock the basic interplay between supply and demand of Science in TV. It is diagnosed that the supply of specialised programmes is predominantly dependent upon financially strong and conveniently structured public service channels, especially the presence of small public niche channels is key to explain the considerable differences of programme offers across Europe. It is further diagnosed that the demand for these programmes by European audiences in general is not sufficient to stimulate production, of special relevance is the lack of appeal for younger viewers. We conclude by identifying main challenges TV producers face when trying to reach the largest possible audience.*

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Resum: *Aquest estudi avalua l'estat actual de la ciència a la televisió i els seus reptes de futur. Les avaluacions es basen substancialment en un parell de media studies empírics comparatius, publicats en l'última dècada, centrats bé en la producció de continguts de ciències a la televisió europea, bé en la recepció d'aquests continguts per part del públic europeu. Aquest treball integra ambdues perspectives en un quadre complet per trobar la clau de la interacció bàsica entre l'oferta i la demanda de la ciència a la televisió. Es diagnostica que l'oferta de programes especialitzats depèn predominantment de canals públics amb finançament fort i convenientment estructurats, essent especialment clau la presència de petits canals públics especialitzats per explicar les diferències considerables en la programació a tota Europa. Es diagnostica, a més, que la demanda d'aquests programes per part del públic europeu en general no és suficient per estimular-ne la producció, particularment en el cas dels espectadors més joves, que mostren una manca rellevant d'interès. Per concloure, s'identifiquen els principals reptes a què s'enfronten els productors de televisió quan es tracta d'arribar a la major audiència possible.*

Paraules clau: *Ciència a la televisió, audiències de ciència, audímetre, grups focals*

Introduction

"While science-in-the media is a useful vehicle for understanding the media", Jane Gregory and Steve Miller wrote 1998 in *Science in Public*, "few scholars have used it that way: instead, they look at science in the media as a way of understanding science-in-the-media and often end up attributing characteristics to science-in-the-media that are simply characteristics of the media, rather than of the science they see there". Science, they concluded, is not a special case in the mass media, understanding science-in-the-media is mostly about understanding the media (Gregory & Miller, 1998: 105). Almost two decades later, research which looks for patterns or even determinants of science-in-the-media, be it in press or electronic media, is still very rare. An interest in explaining the media's selection of science content from a media perspective is weak. Instead, the search for, and analysis of, several kinds of distortions in media representations of science have been leading topics of science-in-media research since its beginning in the USA at the end of the 1960s and remains influential today (Lewenstein, 1994; Weigold, 2001; Kohring, 2005). Only a relatively small amount of research has sought to identify factors relevant to understanding how science is treated by the mass media in general and by TV in particular.

This is not surprising since the methodological requirements of studies which can contribute to a deeper understanding of science-in-media in general are demanding. They must be catholic in focus and comparative. Especially comparisons across countries can provide insights into the reason for degree and structure of the science thematisation. If you saw two

science news items in a prime newscast in Great Britain every day, but none in Hungary, Spain, Germany or Sweden, you had a suitable initial point of reference that allows you to say, that there are *comparatively* many science news item in the British newscast. That then provides a starting point to question why this happens to be so in that place.

The assessments of the current state of science on TV and its challenges that follow are based in substantial parts on a couple of such comparative empirical studies, which I have conducted in recent years (Lehmkuhl *et al.*, 2014; Lehmkuhl, 2013, Lehmkuhl, 2012; Lehmkuhl *et al.*, 2012, Lehmkuhl *et al.*, 2010). The perspective of these studies is not at all compatible with what concerns history of science studies. Their focus was on the production of science related contents in European TV from the point of view of journalism, defined as organized production of messages that can gain the attention of a disperse public. And their focus was on the reception of these contents by European audiences. In this study, I try to integrate both perspectives into a comprehensive picture of the current state of science reporting in TV and its challenges. This study focuses on the understanding of the constraints TV producers face when trying to attract audiences. In more theoretical terms: This paper tries to unlock the "duality of media", using science on TV as example. This means that the same theoretical and empirical approach can also be applied to various other content areas.

Theoretical framework

The term "duality of media" represents an adaptation of the structuration theory of Giddens. It refers to the basic interplay between supply and demand of media content: While people are free to tune into a science programme or any other programme on television, they can only choose from a limited body of programmes on offer, a structure of supply that, through their actions, they help reproduce and alter. Webster termed this basic interplay the "duality of media" (Webster, 2011; Webster, 2009).

An attempt to unlock this duality requires a theoretical clarification of the "media structure" that interplays with media users. In this context, the term refers to a pattern of science programmes offered by various television channels. To profile this pattern and to link it with specific, content-related media use, we need a suitable typification of science programmes that integrates the agency of media professionals *and* media users. A term commonly used in media studies is "genre". Programme genres help media users find their way through various programmes. Genres raise expectations of audiences, supply needs and – at the same time - facilitate media production by helping to establish routines to satisfy audience expectations (Hallenberger, 2002).

Unfortunately, the term "genre" is only of limited value for defining the programme category "science programme" (Bonner, 2003). Since science finds its way into various programme genres, the term seems inadequate for concluding a contract between media professionals and their audiences. Magazine programmes, documentaries, even quizzes or

reality shows are used to raise awareness of science on television in Europe. Hence the term "science programme" is neither suited to describe specific expectations of audiences, nor to facilitate television professionals' selection and reconstruction of science content.

Other available categorisations regarding science journalism are also ill-suited to mediate between production and reception of science on TV because of their science-centricity. The typifications of Haller (2008, 1999), Peters (1994) and – to a lesser degree – also of Secko *et al.* (2012) are guided by the differentiation of the image of science that appears or of what type of science is prevalent in reports. There is less or no focus in these classification attempts on journalistic constraints that arise from the dependency on a large, non-specialist audience for journalism that must be reached by producers in order to pay back the investments in the programme.

The main theoretical challenge thus lies not primarily in the definition of what a science programme actually is. This can be done by a nominal definition. In this context, a science programme is defined as:

a) a programme that reports on research findings or events related to the natural and social sciences, humanities or to applied sciences such as engineering and medicine (Bauer, Petkova, Boyadjieva, & Gornev, 2006; Bucchi & Mazzolini, 2003) **and/or**
b) a programme that links scientific expertise or scientific findings related to the natural and social sciences, humanities, or applied sciences such as engineering and medicine with social, political, economic or everyday topics (Hijmans, Pleijter, & Wester, 2003).

A programme is considered a science programme if it mainly or exclusively covers science content in one of the ways stated.[2]

The main theoretical challenge is to achieve a meaningful breakdown of the heterogeneous body of programmes covered under this nominal definition by the routines they use to establish and protect the bond with their audiences. In this context, we need to turn to theories on how journalism protects its bond with audiences in general and with science audiences in particular, and the different ways in which organisational units like science programmes are trying to attract attention for their products.

Basically, journalism in general is guided by the necessity to gain attention for its products (Luhmann, 1981; Gerhards, 1994; Görke, 1999; Kohring, 2005). Attention for messages depends on the informational value. A statement is informative if it is "new", i.e. if it was previously unknown to the recipient (Ott, 2004). Attention also depends on the relevance to the recipient (here relevance is understood in the broad sense of being useful for whatever sake). Only what is informative *and* relevant, can gain attention (Merten, 1973).

2. For further explanation, please download "Definition of Science Programmes" from our website. www.fu-berlin.de/avsa

Informational value depends on the context and is in the eye of the beholder. What is new and relevant for a certain individual might be already known and irrelevant to another. Hence, there are endless messages, which could potentially gain attention. In order to produce messages that can gain attention of disperse publics, producers must follow routines in their selectivity. These routines serve to protect the bond between journalism and its audiences (Rühl, 2002). Lublinski (2004, 2008, 2011) studied three German radio science programs and a news agency extensively through participant observation. He summarised numerous routinized journalistic actions by the term "editorial concept".

Basing on these theoretical considerations we have screened TV science programmes in 11 European countries that were broadcast between 2007 and 2008 on channels that reach an accumulated market share of 85 per cent in each country (Lehmkuhl *et al.*, 2012). We typified the 439 programmes identified empirically by distinguishing five different editorial concepts, i.e. different ways of how these programmes try to produce new and relevant messages. Three of these concepts will be discussed in greater detail:

A Information Programmes

These programmes tend to be produced by journalism that is specialised in observing news from the field of science, choosing those that seem especially useful to its audience, for example because they concern many people, and processing the selected topics quickly. Another characteristic of this type of programme is that it is specialised in the linkage of relevant non-scientific news items with science. This is the case when, for example, a natural disaster happens, toxins are discovered or the stock exchange crashes. To gain attention in this case, programmes are forced to gather quickly scientific background information about an event or the context of an event and to broadcast it. Accordingly, features within this programme type are very often prompted by current events from within the science system. Furthermore, recent events from within other social systems or the physical world (catastrophes, for instance) often prompt media products in this programme type.

The short preparation time determines how the selected topics are processed. Highly standardised genres such as news reports are commonly used by programmes in this category. Also used are genres which do not need a long preparation time, such as interviews or discussion between the presenter and a reporter/journalist in or outside the studio.

Constraints of short preparation time are also reflected in the average lengths of the items within this programme type. These programmes tend to concentrate on shorter items, not longer than seven minutes. Short preparation time, specialisation in observation of current events from within the science system and more items per episode compared with the mean of all other programmes implies that these programmes cover a variety of themes per episode and they focus more strongly on themes than on a scientific discipline.

Because of its close relationship to current events and the lack of a specified need to be fulfilled by these programmes, we will call this type of specialisation "Information on

Science". The programmes fitting this category we call "**Information Programmes**" (on Science).

B Popularisation Programmes

These programmes tend to be produced by journalism specialised in stories which are not new in a chronological sense but which belong in the wider context of scientific fields. Examples are documentaries about the birth of black holes, the origin of humankind, the history of the theory of relativity, in other words, stories on more or less big themes in science. They attempt to offer deeper insights into fields of science that would otherwise be closed to wider publics. Accordingly, these programmes are characterised by long preparation times and concentration on a focal theme. This kind of programme faces a completely different challenge from that of Information Programmes.

The main challenge does not lie in the selection of relevant scientific news and a quick reconstruction, but in the development of communication techniques which engage the media user with a topic relatively intensely. Generally this type of programme has no convincing answer to the question of why a media user should engage with relativity theory, black holes, the Egyptians or human evolution today of all days. It needs more airtime and demands more attention than a concise report. Two thirds of items within this programme category are longer than 20 minutes. The large majority belongs to the genre "documentary".

This form of relaying information can be seen as an effort to depict science as a fascinating journey to the frontiers of knowledge or as an adventure. This is sometimes even evident in the titles. One of the most common means to spark and kindle fascination is to reconstruct the actual process of finding, to retell wrong turns that were taken, to depict scientists like the heroes of a drama. The dramatic arc in this case is generated through asking questions that are supposedly unanswered. In the course of the programme the questions are addressed and answered, which creates the impression of witnessing the solving of a mystery. What creates the fascination here is either the sensational property of a question or the sensational way in which answers are found, or both. This produces an appearance of adventure that is to a certain extent typical for these formats (Collins, 1987; Silverstone, 1984).

Even more than information programmes the thematic focus of the items within this category is on science. The content can clearly be linked to the formal production of scientific knowledge within disciplines and scientists appear far more as main actors than in other programme types. This corresponds with what has been said about the important role scientists play in the narratives developed. Thematically, this programme type focuses more often than other programme types on humanities, i.e. predominantly history and archaeology, which have been classified as humanities. This type of programme is specialised in the neat relaying of scientific insights and we will call it therefore "**Popularisation Programme**".

C Edutainment Programmes

Programmes can also specialise in using unfamiliar scientific explanations to enrich people's experience of things that are, in a broad sense, part of their everyday life. This type of programme often answers questions such as why the sun goes down, why one gets wet more quickly in the rain when running, what happens if one places a broom stick into a specially prepared blender or sticks one's head into a bubble of helium. The selection of topics, unlike in information and popularisation programmes, is not at all guided by developments within the science system.

These programmes face the task of delivering surprising connections between everyday phenomena and scientific explanations and presenting those explanations in an accessible way. Accordingly, features of programmes in this category are more often prompted by people's realm of experience. The selection of topics, therefore, is hard to organise for media professionals as it cannot be guided by the observation of sciences or other social systems but rather by a programme's specified need. This is the main reason why in many of these programmes recipients propose the topics to be explained. Selections of these programmes are frequently not processed in ways that can be grasped by referring to journalistic genres.

Programmes of this type are characterised by a relatively high share of items that show no link to science at all, i.e. scientific explanations are often only one part of the whole programme. Scientists appear less often as main actors, and entertainers such as singers, artists or sportsmen appear more often than in any other programme type. We will call this type of programme **"Edutainment Programme"** because of its primary outcome orientation, which targets entertainment or education of recipients or both.

Using these rough distinctions of editorial concepts, I would like go on to describe the current state of science on TV below based substantially on juxtaposing the supply of these programmes in eleven European countries (Lehmkuhl *et al.*, 2012), the use of these programmes by aggregated audiences in ten European countries (Lehmkuhl *et al.*, 2014) and on selected judgements of audiences derived from 40 focus group discussions conducted in five European countries between 2009 and 2010 (Lehmkuhl *et al.*, 2010).

Current state of science programming in Europe

Television in Europe is generally characterised by relatively few specialised programmes that would qualify as information journalism, i.e. those that pick up recent events in science and process them into news-shaped journalistic products. About seven per cent of the 439 science programmes that have been broadcast in 11 participating countries[3] between 2007 and 2008 are dedicated to information journalism. Hence, the chances for new scientific findings to be picked up by a specialised TV science journalist and published are slim in Europe.

3. Germany, Austria, Finland, Sweden, Estonia, Greece, Spain, Bulgaria, France, Great Britain, Ireland.

To understand what this means, one has to be aware that information journalism on science requires a specialised editorial unit to provide relevant news from the realm of science *regularly*, that does nothing else other than collecting and distributing relevant news events from the sciences. Because a specialised editorial office or unit does this on a regular basis, it accumulates expertise; it develops efficient routines to find relevant news items, it develops assessment valuation standards that serve to distinguish relevant from irrelevant news items; it accumulates knowledge about research progress in the particular fields of science observed (Lublinski, 2011).

It does not mean that science news is never on television if these specialised programmes did not exist. In fact, science items can be regularly found in television news (León, 2006, 2008). It rather means that there are only few units in Europe, that are *specialised* in the handling of science news items in the before mentioned way.

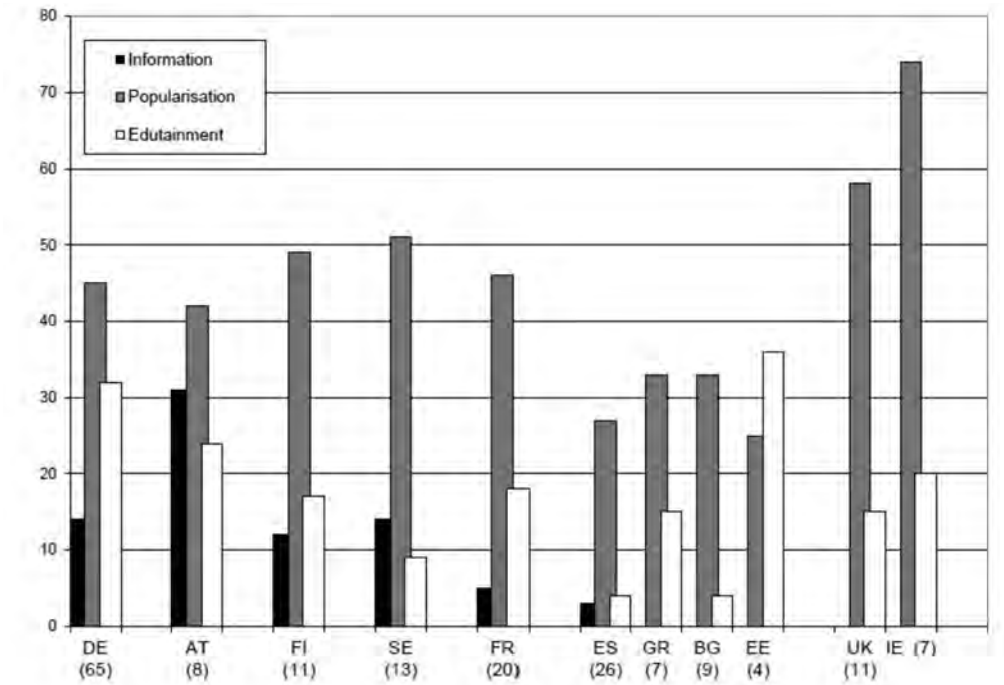
Subsequently, television is organisationally ill-prepared for the handling of new science findings. Usually, television is totally surprised by potentially ground-breaking findings. From virtually nowhere a significant finding suddenly appears, and in the face of the evident importance, the news editors absolutely have to report on it. But they do not possess any established routines how to do this. Instead, they apply the routines they use with their bread-and-butter issues of politics or economics, but unlike political events, they have little expertise in communicating science news in a high quality way due to the lack of specialisation. To achieve high quality, thorough background knowledge is indispensable. Without this background knowledge, for example, it is not possible to evaluate scientific findings. In some cases, the extensive lack of specialised units can have far reaching consequences which is well exemplified by the case of the "Venus of the Swabian Mountains" (Lehmkuhl, 2009a).

As table 1 indicates, information programmes are not evenly distributed in the 11 countries analysed. Only a few countries have specialised editorial TV offices at all, and hence specialised expertise for the selection and publication of science news. Among those are Germany, Finland and Sweden (Austria is a special case that is discussed in detail elsewhere Lehmkuhl, 2012). In these countries programmes are established that address science news regularly.

The lack of specialised editorial offices means that the specialised treatment of science news constitutes a threshold of specialisation that TV can only cross in exceptional cases. Specialised editorial offices have only been found on media markets, which have two features in common:

a) They own thematically specialised public service channels that can live off with low market shares between one and five per cent market share, and (closely related)
b) public service broadcasters do not depend substantially on advertisements and are comparatively well funded by a fee.

Table 1. Distribution of Science Programmes in Europe in per cent airtime



The table show the percentage of airtime in an average week between 2007 and 2008 dedicated to the three programme types considered here. In brackets the total time per country dedicated to all science programmes in hours per week. DE: Germany; AT: Austria; FI: Finland; SE: Sweden; FR: France; ES: Spain; GR: Greece; BG: Bulgaria; EE: Estonia; UK: United Kingdom; IE: Ireland.

The popularisation of science compared to information journalism in television is much further developed as measured by the number of programmes and the share of airtime dedicated to this type of science journalism. In 262 of 439 TV programmes that have been counted in 11 European countries, science was popularised. As was the case with information programmes, popularisation programmes are not evenly distributed across Europe. Differences of supply of this programme type across countries are - by and large - associated with the same factors as was the case with information programmes. These programmes generally deal with a single scientific theme or thematic area without any topical relevance that is edited in a more or less complex way with the means of television. Many of these programmes have been and are distributed Europe-wide, especially BBC series, for example "Planet Earth" or "The Planets."

Accordingly, in science popularising journalism individual programmes or series with four to twelve episodes dominate the market - very different to information programmes that used to be scheduled weekly or even daily on a regular basis. Unlike information pro-

grammes, the popularising programmes are not backed by an editorial office in the classical sense. In that respect the number of programmes does not indicate the existence of a specialised editorial office (as it would with information programmes), because in theory every channel can distribute a multitude of these programmes, without employing a single TV author, that produces such content regularly and subsequently could be considered specialised in the communication of timeless beautiful science matter with mass appeal.

Whereas the information programmes prefer stories related to medicine, the structure of topics is completely different in popularisation programmes: history, palaeoanthropology, archaeology and contemporary history prevail. About 50 per cent of all popularisation programmes address these topics. After a big gap, physics, especially astronomy, follows with 13 per cent of programmes of this type. This means that the thematic restrictions in popularising programmes are great. Not every scientific topic has the same chance to be popularised through TV.

As is the case with information programmes, the lion share of programmes are broadcast by small (1-5 per cent market share) public service channels though with the exception of Ireland and the UK, both countries that cannot be classed to countries with a segmented market of free to air public service channels.

Apart from the UK, where the lion share of science programmes was scheduled on Channel Four and Channel Five, commercial channels did not contribute substantially to the provision of science programmes in general. They account for 20 per cent of all science programming in our sample of countries. The supply of commercial channels is – again apart from the UK – dominated by Edutainment Programmes that seem to be the only type outside the UK that is interesting for commercial TV stations.

In edutainment commercial TV succeeded especially with advertisement-relevant target audiences. A good example was the Spanish programme "El hormiguero" on the station Cuatro in which a likeable, mad scientist character named Flippy demonstrated spectacular experiments to millions of Spaniards. Worth mentioning are also some formats that were developed in Germany: "Clever", "Galileo" or "Wissenshunger". That 56 per cent of the 80 million Germans have seen at least one episode of "Galileo" within the period of one year highlights the popularity that these programmes can gain in some cases. That makes "Galileo" the science programme with the biggest coverage in entire Europe.

It is notable, especially regarding the commercial programmes of this type, that they connect scientific explanation with every day phenomena in only a limited way. They no longer aim primarily to provide the viewers with a light-bulb moment, when they learn that the dancing water drops on the hob have something to do with the water's surface tension for example. Instead, these programmes aim rather for the wow-factor, by manipulating the every day phenomena that are to be explained, in such a way that they become spectacular. This is the case, when the braking force of common car breaks is demonstrated by braking a car by parachute. This is also the case when the power of a household blender is docu-

mented by first preparing it so that a broomstick fits into the blender and bursting the broom stick with the force of the blender.

Also fairly typical for commercial edutainment formats is that it uses a broad definition of what counts as everyday experience and subsumes under this also phenomena that are from the realm of the mysterious. These "mysteries" can be assumed to be known by many people. Such "phenomena", like Chakras or time travel, are then (para-)scientifically explained, sometimes with scientific experts taking on the role of explainers. There might be an argument here that such programmes cannot be included in the catalogue of scientific formats. One argument against the exclusion of these programmes is that their narrative techniques have entered into classic science programmes (Lehmkuhl, 2008).

However, edutainment is a German speciality. By far in no other country so much airtime was dedicated to this editorial concept. One factor, although difficult to grasp, that explains the exceptional role of Germany in this programme segment may be the tradition of science reporting in audiovisual media in Germany, which was since its early days strongly connected with programme formats which today we would class as edutainment programmes (Cube, 1994). But we know little about the historical roots of science programming, which can be connected conceptually with preferences regarding how scientific information is selected and broadcast by producers. It remains therefore rather difficult to assess to which extent understanding differences in the traditions of science broadcasting in media contribute to a deeper understanding of the choice of programme types.

Easier to grasp is one difference of Germany compared to all other countries in our sample: The comparatively big number of mid-sized commercial channels that can live off with market shares between 5 and 10 per cent, which – of course – correspond to the size of the German market with its 80 million inhabitants. Overall, we found that science programmes on commercial channels tended to be broadcast on mid-sized channels. Almost two thirds of total airtime for science programmes on commercial channels in general was allotted by mid-sized commercial channels. This means that volume of supply especially of edutainment corresponds with a characteristic of national TV markets as was the case with popularisation and information, the existence of mid-sized commercial channels obviously increases the probability that edutainment programmes are offered.

The interplay between supply and demand

In the previous paragraph we have identified some characteristics of national media systems that can be linked to the structure of supply of science on TV. Next we will expand the analysis by integrating data on the use of these programmes in Europe. This is especially relevant for the TV market that is driven by various audience measuring tools, the most important of which are daily television ratings derived from people-meters (Koch-Gombert, 2010). These measuring tools actually enable a vivid interplay between supply and de-

mand. I propose to treat aggregated audience data as the most relevant currency for producers of TV content. Of special relevance are data from young audiences, aged between 14 and 29.

Particularly commercial channels view their audiences primarily as merchandise to be offered to the advertising markets. Young people are of particular interest here, since their consumer behaviour and needs are considered more manipulable than those of older people. Particularly for public television, young audiences play a significant role in assuring the channels' very legitimacy: almost Europe-wide, public television is bound by the double normative mission of appropriately integrating science and education into its programme portfolio, and reaching all age groups in society in order to act as an integrating force (Open Society Institute, 2005; 2008).

The analysis of people-meter data derived from several countries in Europe is a complex methodological issue that is described in detail elsewhere (Lehmkuhl *et al.*, 2014). We managed to create an artificial subsample of ratings of science programmes, which enables meaningful comparisons of ratings of different programme types. The sample controls important factors that influence audience rates independent of content, namely the viewer awareness (programmes scheduled on small channels have not the same chance to reach as much people as programmes on big channels), the number of channel options in a country, and the viewer availability that refers to seasonal, weekly or hourly variations of the size of the potential audience.

By using this sample, I will firstly compare the average rates each programme type category reached between 2007 and 2008.

Table. Average viewing rates by programme types in 10 European countries*

Programme Type	Average Viewing Rate in %	Standard Deviation	Number of Programmes
Information	1.9	2.1	10
Popularisation	1.2	1.5	115
Edutainment	1.3	1.6	43

*Austria, Bulgaria, Estonia, Finland, France, Germany, Greece, Ireland, Spain, Sweden

The differences between the three programme types considered here are slim, the average rates do not differ significantly. Hence, there is no evidence that the bare size of audiences can be related to the programme type offered. The same is true when we consider the average share especially of young audiences (14-29).

Table. Average share of young viewers (14-29) by programme types in 10 European countries

Programme Type	Share of Viewers 14-29 in %	Standard Deviation	Number of Programmes
Information	9.6	6.2	10
Popularisation	11.1	10.4	115
Edutainment	15.8	11.1	43

Though on average the share of young audiences watching edutainment programmes is considerably higher than the share watching information programmes, the differences are not significant. This is certainly due to the low number of information programmes. However, there is no convincing evidence that the low shares of young science audiences are related to any specific programme type. Instead - with regard to the production sphere mostly relevant - the programme category "science programme" as a whole did not appear to be attractive to young audiences. Every single science programme type in all ten countries reached a considerably lower share of young people when compared to their share of the overall population. The share of young science audiences is between 7 basis points (France) and 15 basis points (Greece) lower. Apart from Austria and Ireland, even the share of people aged between 30 and 49 is considerably lower than their share of the overall population (-12 to -7 basis points).

I will finish this snapshot on audience data by coming back to the meaning of the actions of aggregated audiences for producers. To those in charge of making programmes, the young viewer segment is almost intangible as an aggregate group, as a definable segment of a mass audience with differentiable preferences regarding media reconstructions of science related contents that can be addressed by producers. Only edutainment programmes seem to have a certain appeal to audiences younger than 50.

By taking into account that aggregated actions of audiences help reproduce and alter the structure of supply of science on TV, we found no convincing evidence that audiences inspire the production of science contents in TV on this macro level of analysis. On the contrary, if content production would exclusively be led by audience measures, we had reason to expect a decline of science programmes on offer on a European level. This affects foremost information and popularisation programmes, which lack appeal for younger age groups.

Before starting to conclude on challenges faced by producers of science content, we will try to substantiate our quantitative audience analysis further by selected outcomes of focus group discussions. A team of researchers and I conducted 40 focus group discussions each with 8 -12 participants in five European member states: Germany, Finland, Greece, Bulgaria and Ireland. The composition of the groups was varied regarding a) the

direct access to science (scientists, science teachers, amateur scientists….), b) age and c) education.

The focus group discussions were designed to contribute to an understanding of why participants engage with science through regular selection of science contents in TV and other media. They do it across countries because of

a) the perceived personal functionality of science in media
b) perceived own personality traits (curiosity)
c) perceived characteristics of the medium TV that transmits science content.

In addition, the focus group discussions brought up a set of judgements relevant for understanding the reception of science content dependent upon the programme type.

The discussions reproduced a battery of gratifications audiences expect and receive by watching science on TV which have been reproduced repeatedly since the early 1970s, for instance "Getting insights into something new" or "Becoming inspired to search for further information" or "Gaining interesting things to talk about"(McQuail, 2010). Interestingly, we could not identify any motive, need or gratification that can be linked exclusively to science contents. Instead, expected and received gratifications appear to be applied to the medium TV rather than to specific non-fictional TV contents. Insights into the motives of audiences to watch science programmes are thus not promising with regard to our main interest here, the interaction between supply and demand of science contents in TV.

Promising are the judgements expressed in the discussion groups of each of the three programme types. I will focus especially on statements that illustrate the main challenges of the three different programme types or editorial concepts from an audience point of view. The aim of this analysis was to unfold relevant criteria, which are applied to express specific strengths or weaknesses of the different editorial concepts. These statements have been provoked by showing short clips of each programme type.

The very open question about what they think of the clip led to a multitude of criteria, against which the programme clip has been judged. Instead of repeating all criteria, which are published elsewhere (Lehmkuhl *et al.*, 2010), I will focus on those that appeared to be of crucial importance for the judgments of each of the programme types and will illustrate it by some quotes from the discussions.

To provoke judgements that can be linked to information programmes, we showed – according to numerous studies (Bauer *et al.*, 2006; Bucchi & Mazzolini, 2003; Einsiedel, 1992; Pellechia, 1997) – typical science news reports, i.e. reports on new medical findings that are promising in the sense that they may lead to a cure, a vaccination or more generally to progress. But the results are yet to be confirmed, the actual practical meaning appeared to be ambivalent.

The most important criteria against which negative judgements have been expressed in

all five countries were the meaning of the message, which was unclear. Some Greek participants felt that the medical breakthrough should not be presented as if the solution is already there, otherwise the message could raise false hopes: "There is an ethical dilemma however – scientists have responsibility when presenting a health topic."

The unclear meaning of the message made some Bulgarian participants wonder about the motives of the production team. The same applies to some groups from Finland and Germany. Participants tried to find "a motive" for presenting such news. They oscillated between a conspiracy theory (purposefully presenting the story), spreading fear, urging people to buy vaccines, which would be in the interest of the pharmaceutical companies. The unclear meaning of the message led Irish participants to judge the news report as "filler inner" which would be used on a "slow news day".

German participants shared this impression. One quote taken from a German discussion group well exemplifies the critical judgments in many groups across countries:

> "When something like this gets broadcast in the news my expectations are that something meaningful had happened that should easily be described in two or three sentences – the way news are generally structured – and will give me information on something that will have a positive effect on me. This was simply a filler, providing zero information. 'Could be, could not', looked somewhat appealing, they (the editorial team) filled in the time, they had the topic (AIDS) – and that might actually be the only positive aspect about the whole thing: we're still aware of this topic and are still conscious about the severity of it."

This quote summarises crucial findings of the focus group discussion as far as news shaped information on science on TV is concerned. The critical judgments focus predominantly on the lack of meaning, but the critical judgments are somewhat moderated by the importance of the issue that is addressed. In all countries participants judged the importance of the topic itself, i.e. the disease in question highly relevant and relativized critical statements by mentioning the general relevance of the topic.

It is evident that the expectations of the participants in focus group discussions regarding science on TV are impossible to meet by reports on single scientific findings especially as far as biomedicine is concerned. There might have been single papers, which contained a "solution" in the past, but this character became never apparent when the paper was published. The expectations of participants in focus groups are definitely not in line with what is possible by news reporting on science. This may serve as an indicator that affects the structure of supply as far as information programmes are concerned.

Crucial for the judgments of the popularising clips (cuttings from typical high cost documentaries on astrophysics, evolution and paleoanthropology) was the topic selected. In all groups across countries the topic is the dominant criteria against which popularising TV

contents are judged – positively or negatively – followed by the way of the presentation, which has been both praised and bashed. The polarisation of judgements referring on the topics and on the way of presentation became particular evident in Germany, Finland and Ireland, all marked by a considerably bigger number of popularising programmes on offer compared to Greece and Bulgaria.

Irish participants in some focus groups enjoyed the clip on evolution uniformly, whereas participants in other groups did not like it at all and "couldn't wait for you to switch it off". This was due to the topic chosen as some participants felt evolution had been "done to death".

For Finnish participants who watched a high cost documentary on black holes interest on the topic seemed to have a considerable influence on participants' comments about the clip. Most groups seemed to be divided between those who were very interested in cosmology and those who were not interested at all. Those who don't usually watch space documentaries tended to be critical and found the clip uninteresting and would not have watched the documentary at home: "I almost started to laugh in the beginning. This is an area of science that interests me less than anything else. It is so far away from my life, I don't even understand what is the use of the black hole, what can we do with the knowledge about it?"

German participants who watched a clip on paleoanthropology also praised and criticised the topic. As in Finland, interest in the topic field was the most important criterion. The critics referred primarily to the specialisation of the topic, which requires vivid interest for the subject matter. "Well, this might be an issue for someone who's just read a lot of books on the history of the development of mankind, Darwin – pretty interesting. But I don't see a real benefit in there for me. I link everything to benefit and to the advantages humanity derives from it. It's a programme to watch, but not much more." Or: "That topic doesn't have anything to do with general knowledge in my opinion – that's something you learn in school – what would be general knowledge in regard to archaeology and the finding of some kind of ape is not really general knowledge. I'm interested in sciences, I would say, but rather in like general science, not specifically (…) archaeology and that's why I would have turned it off."

This leads to the conclusion that the importance of the topic for the selection of a popularising programme is the main factor worth considering when trying to unfold the interplay between demand and supply. Everywhere in Europe popularising programmes are very rarely broadcast during prime time by big channels that must reach more than 10 per cent market share. Popularising programmes can only cover one specific topic, however popular this topic might be, it can hardly be calculated whether the popularity of the topic is high enough to jump a hurdle of more than 10 per cent market share or even more. In addition, the relevance of the topic for the success of a programme explains why European broadcasters concentrate so much on historical topics.

To provoke judgements that refer to edutainment programmes we showed clips that provided scientific explanations on "why champagne bubbles?"; "why we need to sleep?" ; "why it is difficult to make computers learn?"; "why water drops tend to 'dance' on a hot-plate?" and "why lightning is dangerous and how it can be explained". As in the earlier cases, the clips and the open question of what they think about them provoked various judgements as it was the case with the other programme types, but unlike information and popularisation programmes we could not identify a criterion against which the clips are judged predominantly.

However, apart from Ireland all groups across countries appreciated the relatedness of the topics to their daily lives, but though the topics address every day phenomena and try to make scientific explanations relevant, many groups questioned how relevant the explanations really are. This became particular evident in Finland and in Germany. Some Finish and German participants judged the clip trivial, childish or ridiculous since the topics addressed lack importance or – as a Finish participant stated - are too "small":

> "I'm not interested in such small things. It is targeted to different kind of people (giving a laugh) who are interested in such small things instead of being willing to understand anything bigger…"

The judgments of many participants especially in Finland and Germany are marked by ambivalence. One the one hand they applied the criterion of the relatedness of the topics to their personal lives, against which the stimuli are judged positively. On the other hand they applied the criterion of the importance of the explanation, in order to qualify their judgement substantially. This ambivalence is illustrated well by a quote taken from a discussion in Germany:

> "Do I really want this information? I'm leaving undecided! But when I see this I'm thinking 'oh! It works like this as well' but you don't reflect on it beforehand..."

To sum up the judgements in most of the focus groups, edutainment programmes are appreciated for providing a light bulb moment, but the importance of this moment, the importance of the explanation is assessed to be rather small, if not trivial. This tendency is well illustrated by a summarising statement taken from a German discussion group:

> "Well, I liked it (the programme from which the clip was taken) as a short teaser, right before the news programme but: I wouldn't watch something like that for a whole hour – I simply wouldn't! But a short teaser like that, sure, why not? It makes me think for a while and then I think: 'ok, that was it for today'."

When we try to link these insights with the structure of supply it becomes understandable why especially popular edutainment programmes depend heavily on the context in which the explanations are embedded, a quiz, a reality show, a family show. It appears to be unlikely that edutainment can gain the interest of audiences when just concentrating on the accuracy or comprehensibility of the explanations and/or on the relatedness to every day experiences. It requires something more to gain attention of TV audiences for scientific explanations.

Challenges of science on TV in Europe

I would like to conclude with a look into the challenges TV producers face, guided by the insights into the interplay between supply and demand of science contents in European TV. I would like to start with the specialised information journalism that has to fight with structural problems.

From a normative perspective, information journalism is understood to have an important societal role because it scans research for events that have at least the potential to be relevant for others outside the field of science that it concerns, such as politicians, that want to reform pensions, health and traffic systems, or entrepreneurs, that want to market innovation, or even scientists that are alerted to trends relevant to them in other disciplines, or people that are suffering from a disease or look for orientation (Field & Powell, 2001).

From the perspective taken in this study, i. e. the perspective of TV journalism that is forced to produce science news regularly that can gain the attention of a TV audience, producers face the problem to meet the normative expectations due to primarily one character of the object under consideration: new research findings are almost always essentially ambiguous, in the sense that their practical meaning - lynch pin of their societal relevance – is rarely clear at the time of reporting. Set phrases are abundant in information journalism; such as: the result, breakthrough or cornerstone xyz *could* lead in three, five or ten years to this or that. It might be possible to avoid such set phrases. But producers of science news cannot avoid the dilemma that new scientific research needs to be relevant for a diverse public, but that this relevancy is almost always uncertain as far as new single studies are concerned. TV producers cannot count on attention if they need to burden their constructions with “mays” or even “mights”. “Scientific uncertainty per se is not attractive to journalists” (Kitzinger & Reilly, 1997:344).

It is exactly this structurally determined property that makes it unlikely that science information journalism could overcome its very marginal position in the foreseeable future, as long as this journalism mainly sees itself as collector and evaluator of (natural) science news who are specialised on the selection and quick reconstruction of things that appear in *Nature*, *Science*, *The Lancet* or *PNAS*. This concept will survive or die with news journalism in general as a marginal phenomenon; real impulses for the future are not to be expected from this concept.

It may be assumed that a gain in status of information journalism depends on its success in raising topics that are highly relevant to society. Ideas, how this could happen, do exist. One such idea is to design information journalism as a watchdog of science. Such ideas can be challenged as they do not consider the expectation of the audience, nor the structural difficulties that stem from the specialisation of the sciences. Journalism would be overwhelmed by the role as a science watchdog.

Other ideas have to be judged differently. These propose to use the accumulated expertise of specialised editorial offices to connect relevant societal topics much more than previously with scientific expertise, or to communicate new insights into relevant societal problems, respectively. This concept had already been discussed in the 1980s by the German philosopher Helmut Spinner (1985). The core of these concepts is to make science usable as decisive resource for investigative inquiries. According to this concept, journalists would no longer proclaim the government's political declaration but also at the same time do a kind of science-based check of rationality, to uncover its ideological contents. This would without question accommodate the increasing need for orientation of its clients.

These concepts, however, would mean a radical change in observational angle. The search would no longer be event-related (to new scientific studies) but instead problem-related – with respect to relevant scientific expertise. Not journalistic experts in certain scientific disciplines would be in demand but excellent investigators with scientific expertise in many disciplines including especially the social sciences and humanities. Furthermore, journalistic expertise would not be organised into science departments but instead all reporters need to possess scientific expertise.

There are many reasons to doubt that such a radical change would be possible within the current structures. But in my view there is no doubt that the challenges of the specialised information journalism will not primarily be addressed in the few TV science units but in the editorial offices of politics and/or business. This applies to all media, not only to TV. The TV information programme of the future will rather follow the format of the US show "Frontline" (www.pbs.org/wgbh/pages/frontline) than the classic "Vetenskapsmagazinet" on Swedish television or "Nano" on German TV. They practice investigative journalism that uses scientific expertise on a case-to-case basis.

The main content related feature of *popularisation programmes* that serves to understand the contemporary interplay of supply and demand is their focal theme approach. Pivotal to all popularisation programmes is their focus on one single scientific topic that is costly constructed and their need to keep the attention of TV users for a relatively long span. This character explains well why these programmes are extremely selective in their choice of topics and why reliably reaching big TV audiences is so challenging for these programmes.

It is unlikely that popularisation-programmes can overcome this restriction in the future. This would be different, if journalism suddenly were in a position to re-evaluate popularisation with topical references.

What conditions are needed for this to happen and what possible consequences this opportunity would have for public attention and for science itself, can be demonstrated with the examples of science-media-partnerships (Nielsen, 2009) for which the case of Ida is a good example. Ida is a primate fossil that kept not only information journalists all over the world busy in the summer 2009 but was *at the same time* popularised through a book and a television documentary. I do not know of any other case in which a single scientific finding has received so much attention. By autumn 2009 the scientific article that describes the findings had been downloaded over 100,000 times from the server of the online-magazine *Plos One* (Franzen *et al.*, 2009; Lehmkuhl, 2009b; Mäder, 2009). This makes it probably the most popular scientific publication of a single finding that has ever been published.

Although especially popularisation programmes may amenable to science-media-partnerships it cannot be expected that such partnerships will solve the main challenge of engaging big audiences. This, of course, does not mean that popularising contents in the long-term will be produced in the same way they have been so far - it is rather very likely that maybe innovation in camera technique or something of that kind will result in new possibilities in visualising or the like. However, this does not essentially change its basic conceptual orientation. The main concern in the future will still be to find the largest possible audience for a specific science topic of timeless beauty.

Currently, the degree of popularisation in non-pay TV depends largely on the supply side on the number of specialised public service stations that can live off or make do with a market share of between 1 and 5 per cent. The more such stations are available in a country, the more popularising programmes are broadcast. This applies to those European countries whose markets are big and/or whose public service broadcasting is financially relatively well equipped. Especially the thematically specialised public service broadcasters are dominant in the popularisation on TV; this is especially visible in Germany, France and Scandinavia. Considerably more popularisation can be expected in the near future in Great Britain due to the establishment of digital special interest channels supported by the BBC from a very big available pool of popularising contents. Especially in Great Britain the degree of popularisation in 2007 and 2008 was still limited due to the low number of free to air TV channels.

This suggests that a Matthew effect will apply in popularising TV-contents: Those who already have are given even more. The situation in South and East Europe is different and more difficult. It is to be expected that the segmentation into niche TV channels would have a similar effect, but there is reason to doubt that a comparable niching into special interest public channels will occur at all. The public service broadcasters in these countries are generally very under-funded and the markets for national commercial niche channels are too small. The German market is the only market in Europe in which commercial broadcast associations entertain also niche channels that have popularising contents to an appreciable degree. And even there, the channels are usually loss-making. It can therefore be assumed

that more popularising content in these countries would only be possible with operations/activities of foreign-based broadcasting associations. This certainly will have no or little effect on the amount of popularisation that is produced in these countries.

Edutainment has the greatest potential, conceptually as well as economically. Edutainment in Europe is rather dynamic. This is evidenced by the fact that new formats are published regularly. The reason for this is twofold: edutainment offers a new option to re-evaluate established TV genres such as the family show, the quiz show and even reality TV in regard to concepts and contents. Furthermore, the combination of existing TV genres with explanations offers the possibility to plan the popular success of these developments more reliably than that is possible with popularisation which appears to be heavily dependent upon the topics selected.

For this reason, edutainment is an option to cover the segment of science especially for commercial providers. Public service broadcasters are less dominant in edutainment than in any other type of science journalism. The potential that this type in all its variations has for TV is not exploited in all European countries as our comparison has shown. The stronger establishment of edutainment (unlike popularisation) is not prevented by primarily economic constraints in Scandinavia, East or Southern Europe. Additionally, the popularity of edutainment is not confined to a clear-cut cultural area, as can be seen in the successful internationalisation even outside the borders of Europe of German formats such as "Clever". Thus, we can expect that the presence of edutainment in European television will increase in the medium-term.

But this does certainly not mean that this is of any societal relevance. Each of the concepts distinguished here includes a body of programmes that are to some extent quite heterogeneous and differ from each other in various ways within the categories we selected for this study. This is particularly true for Edutainment, which enjoys the highest share of young viewers.

There are many different ways to link concrete scientific explanations to real-life experiences in the broadest sense. The English programme "Rough Science", for example, sent scientists to a deserted island for several days and had them solve various everyday problems there. Other Edutainment formats also relied on a manipulation of the everyday world in order to stir interest. Still others focused on the scientific, limiting themselves to an explanation of factual everyday phenomena such as why we sleep etc. Edutainment programmes can thus be further differentiated by whether they use an interesting scientific explanation to connect with the audience's interest, or whether they seek to maximise the interest value by manipulating everyday life and relegating the scientific explanation to the sidelines - which raises the question as to whether they ought to be counted among science programmes at all.

We find indicators that it is mainly the latter type of the so-called Edutainment programmes that reach the highest numbers of young viewers. We further find indicators that

the explanation in itself is not of great importance to explain the popularity of the programmes. The very successful programmes in this group with a share of young viewers of more than 14 percent contain a significantly higher proportion of segments in which the link to science becomes very indistinct. The discussions in focus groups also underline partly that the value of scientific explanations for audiences should not be overestimated, it seems unlikely that edutainment can become an appreciated part of the daily TV diet of consumers.

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SCIENCE TELEVISION IS JUST TELEVISION

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"Television: the human fishbowl"
Ramón Gómez de la Serna (1955)

Abstract: *This paper focuses on television, and not on science. It basically draws on my own experience as a director of a science program (*Tres14*) in the Spanish Public Television Corporation (*Televisión Española*). To start with, I will look into the fact that television professionals do not have to undergo scientific training in order to become science broadcasters. The consequences of this concerning the production processes as well as the structure and content of the final products will be discussed. Indeed, broadcasters learn science while producing science for television. Yet, it is essential for television professionals to understand or, significantly, like the subjects they cover. This paper discusses how these elements make science broadcasting a quite particular journey. In the end, a program about science is just, and no less thau, a television program, and most comply with the same estrategies and rules that are common to other television genres.*

Keywords: *science, television, popularization, popular science programs, science content production*

Resum: *Aquest article parla de televisió, no pas de ciència. De fet, es basa en la meva pròpia experiència com a directora d'un programa de ciència (*Tres14*) a Televisió Espanyola. En primer lloc, s'analitzarà el fet que els professionals de la televisió no necessitin d'una formació científica per esdevenir divulgadors de ciència. També es*

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discutiran les conseqüències que es desprenen d'aquest fet, tant pel que fa als processos de producció, com a l'estructura i el contingut dels productes finals. En efecte, els professionals de la televisió aprenen ciència alhora que produeixen ciència per a la televisió. No obstant, és essencial per aquest entendre o, si més no, que els agradin les matèries de qui tracten. L'article reflexiona sobre com aquests elements fan de la divulgació de la ciència una aventura peculiar. Al cap i a la fi, un programa sobre ciència és, ni més ni menys, un programa de televisió, sotmès a les mateixes estratègies i normes que la resta de gèneres televisius.

Paraules clau: *ciència, televisió, divulgació, programes de ciència, producció de contingut científic*

Introduction

This paper focuses primarily on television, on production processes aimed at creating small screen narratives about science. Therefore, it is not so much about science itself and its popularization or, for that matter, the popularization of any kind of knowledge on or through television. What follows is an extended version of the talk I gave on May 16th, 2013 at the 7th European Spring School on History of Science and Popularization: Science on Television, that took place in Maó (Minorca, Spain). The School was an uncommon chance to exchange points of view and experiences between scholars coming from the fields of history of science and communication studies; television professionals, like myself; and the students in attendance, among whom there were also academics and media professionals, including a few people interested in the educational traits of what we call, quite broadly, science on television. Indeed, the aim was to explore the thematic and narrative intersections between science, or the processes of generation and circulation of scientific knowledge, and television, or the processes aimed at generating meaningful approaches for the circulation of scientific knowledge.

At the School, I gave a talk about my experience as director of a science television program (*Tres14*) in the Spanish Public Television Corporation (*Televisión Española*, TVE hereafter). Here, I have sought to mull a little more in depth over the issues I offered for discussion in Minorca. My starting point is the fact that it is not possible to make a television program without understanding the subject matter of the program, what is shown, whether scientific or not. I argue that a science television program is, first and foremost, a television program. To make programs about cooking, architecture or economy is a complex matter, yet the rules concerning approaches and outcomes are practically the same. In the end, content has to be interesting and it has to look alluring.

In the following pages, I will try to put in plain words some of the techniques, the ones that, in my opinion, are the most relevant, that I take into account when producing and directing the program *Tres14*.

The case study: *Tres14*

Tres14 is a science popularization program intended for the general public. It has been broadcasted weekly on TVE's channel 2 (*La2*) for 4 years (2008-2012), every Sunday evening at 8:30 pm, and it is back on air in September 2014[2]. We have so far produced a total of 189 programs. Its episodes are 27 minutes long, monographic, and have no anchor. This program has always sought the most suitable formula for television to present scientific content. In my opinion, it is a fresh, groundbreaking approach that has got a faithful and increasing audience. Indeed, it has become the most followed television science program in Spain.

The basic aim of this paper is to explain why and how the format of *Tres14* is done as it is, which amounts to giving an account of the experience of building and developing the program over the years.

The concept

A television program must have, in the first place, a root idea, a generic purpose, just like in a novel, a film, or an essay. In the case of *Tres14*, the assignment was to make an entertaining science television program, not intended for a specialized audience, any kind of elite, but, instead, for the general public. The catch was, at the same time, the constraint to carry it out with a very tight budget. Given these premises, the first task was to define the spirit of the program, what in essence was going to set it apart from the rest of science programs that had been previously broadcasted or that were on air at the time. The defining idea, the approach I thought up, was to talk about the world around us, the world we inhabit, from a scientific point of view, to be sure, but as something that we are part of, not alien, a *human* program, rather than a *scientific* one.

What is the point of making a *human* program? By what standards were we establishing the difference between *human* and *scientific* when it comes to qualifying the spirit of a television program? Firstly, because there are and there have been already too many television approaches to science featuring grave men in lab coats, mathematic formulae and futuristic music. And secondly, in our particular case, because the budget, as mentioned, did and does not allow us to plan and carry out great trips or shootings in order to film the 'spectacular science'. The assignment was to make a science program for the general public, and wider audiences do not identify with lab-coated scientists.[3] There is a *greguería*[4] by Ramón Gómez de la Serna that serves as a succinct illustration of the spirit, the starting concept of

2. <http://www.rtve.es/television/20140908/nueva-temporada-tres14/1007500.shtml>

3. Despite so many such depictions, not only in documentary films and television programs, but also in fiction films, notwithstanding the wide variety of approaches and narratives.

4. A greguería is peculiar type of aphorism, created and developed by Ramón Gómez de la Serna, which always included a socio-cultural and or mildly political commentary.

the program, which I used to start the paper: "Television: the human fishbowl". That is, the place where we, human beings, watch human beings just for the sake of sheer pleasure.

This simple idea of the human spirit of the program implies making many key decisions concerning content, subject selection, approach(es), visual treatment and language, apart from the selection of shooting locations and other aspects concerning the contextualization of the messages. Yet, it is important to point out that *Tres14* is not an entertainment program, but a science popularization program that aims to be as entertaining as possible. We would need a high budget, anchors, actors, a television studio, or, to put it ironically, elephants, perhaps a rocket, in order to make proper science entertainment. In all, we would need money because entertainment is spectacle.

From these premises, I will try to spell out the main features of the *Tres14* formula, an approach that has been developed and fine-tuned over the years according to the highly exploited trial-and-error method.

The *Tres14* formula

The purpose of a television program is only one and always the same: to reach the viewer, to get upward audience ratings, to make the number of viewers increase while on the air, what is commonly known as a growing audience curve, to build the viewers' loyalty, that is, to bring them back to watch further installments. This is not to say that anything goes in the name of audience ratings, yet the fact is that, without viewers, television does not make any sense.

In other words, it is necessary to avoid boring the viewers, to keep them interested throughout the broadcast, and to get them to come back the next time. Therefore, this is a tale of seduction. And, in order to achieve this seduction, we have a number of technical and narrative tools, all of them equally important, to play with and combine properly: content, audacity, images, clarity, rhythm, beauty, color, music, empathy and poetry. All of them have to do with the abovementioned selection of subjects, approaches, language and visual treatment. I will discuss them, one by one, giving some examples from *Tres14* to illustrate them.

Content

The spirit of the program, as defined above, has to be taken into account when selecting the subjects. It is not just a matter of choosing from current affairs or what is fashionable. Yet it is necessary to bear in mind the possibilities (and limitations) a subject matter offers in terms of time and the medium, that is, a 27-minute television slot. We know by experience that the subject matters that work best are the ones related to health, technology, the brain and the universe. There is a lot of research going on about these themes, they generate lots of questions and people perceive them as close to their everyday lives. Yet, it is the popularizer's job to tackle other, uncommon subjects, and present them as close or interesting as the former. It is also the popularizer's job to frame these topics. The available time and the complexity of the subject matter will help us to determine how far or deep we can delve into

it. In addition, the visual potential is also decisive, as well as the possibilities it offers to link it to the viewers' everyday lives, to *real* life.

For instance, we have chosen, earlier, mathematics as a subject matter.[5] It is not necessarily a visual topic, as it is abstract and requires lots of graphics that could be quite boring. So we decided to tackle it as something tangible, such as security issues with credit cards, and from there pointing at all the math there is in real life and we, unaware, use all the time.

Perception is another example, to look at how we perceive things.[6] It is a visually challenging program that needs a lot of visual metaphors. However, the topic can be easily linked to the viewer. Our approach was to tackle perception from magic, focusing on how we get or do not get (fooled by) tricks, and then beyond, on the problem of how tricks do not fool people with autism. These kinds of approaches help illustrate and explain what we know about perception and attention.

Another illustrative example is a program about the management of space, *Tetris*[7], where we focused on the verb 'to fit'. Management of space is an essential feature in everybody's life, individually and collectively. And it is a highly visual subject that responds to many aspects of a globalized world, from how freighters are loaded to how a piece of furniture can be folded over into a minimal package, or to how successfully play the Tetris videogame.

The aim of all these programs is not so much to make the viewer find an answer to the classic question 'what is it for', but to make them feel part, and not just as observers, of the world science explores. Thus, we look for content both from scientific literature and elsewhere. This is indeed part of the spirit of the program as introduced above, that is, to look for worldly subject matters, not only coming from the world of the scientific research that is carried out. The program about management of space I just mentioned was suggested by a whole season of the well-known television series *The Wire*[8], which was centered on the management of cargo ships in a mafia-controlled harbor.

In order to get this kind of content successfully through a monographic program, we try, whenever possible, to address it transversally. Themes as diverse as movement, the sky, life, the sun, water or freedom thus become sort of files. Regarding water, for instance, the focus can be on cleaning systems, water collection systems, glaciers, ecological homes, cactus gardens, salmons, the problems of access to drinking water, etc. So many different fields of research, so many questions and results, are involved and can be combined, all them clearly distinct and yet related. To be able to treat a theme transversally, whenever possible, is

5. *Seguridad* [*Security*]. Broadcasted on June 20, 2010. <http://www.rtve.es/television/20100614/seguridad-tres14/335455.shtml>

6. *Prestar atención* [*Paying attention*]. Broadcasted on April 5, 2010. <http://www.rtve.es/television/20100330/atencion-tres14/325861.shtml>

7. *Tetris*. Broadcasted on September 26, 2010. <http://www.rtve.es/television/20100920/tres14-aire/355336.shtml>

8. *The Wire*, season 2 (2003).

essential for popularization. In the last two centuries, science has taken the path of specialization, compartmentalizing areas of inquiry. However, we are now looking for connections. Specialization on television works well for particular kinds of viewers interested in particular subjects. Yet, we may risk loosing all the rest, the vast majority of them. A plural point of view captures more viewers as it addresses a variety of interests. This allows us to talk about physics, chemistry, botany, and astronomy in the course of just one program. Furthermore, specialization bears yet another risk on television, which is the conveyance of excessive complexity. Television is not a medium for complexity. It is not built with specialists' papers; it is, instead, a generalist medium. We cannot count on the viewer's professed will, and, on top of that, we compete with many other television channels and other media and platforms, such as the internet, notwithstanding the common occurrences of domestic life, the phone, an assortment of noises, the family.

Images and audacity

Television cannot be done without images. What I mean by this obvious assertion is that we need to be able to visualize the subject. A good part of the popularizer's job is to think about those images. In a certain way, anything goes, such as family videos, historical archive films, or dream short films shot with a cell phone camera. The key lies in making such a wide variety of materials to fit and make sense. Actors, graphics, cartoons are among the most obvious resources we can count on to build these images. The point is to have the audacity to find original images and narratives. Audacity is the only way to find new ways of presenting any kind of knowledge, of content. If we limit ourselves to spell out content in a straightforward, comprehensible way and do not try new approaches, we will never find something really innovative and/or better. For instance, and I write this perhaps with a bit of deliberate exaggeration, scientists treat themselves reciprocally with a lot of distance, with detachment, in *serious* programs; these, and they, the scientists, do not sound like rock 'n' roll. Breaking the rules, that is, for instance, making scientists play, ask them to act or speak in unexpected ways, even from a completely different standpoint; to dare illustrate science with amusing images or soundtracks that do not fit with traditional genre expectations, is a sure path to either failure or, better, actual innovation. Having the audacity to surprise the viewers, to pose them challenges and new languages to decipher is undoubtedly risky, but hopefully fruitful as well.

Clarity

Yet, clarity is crucial in the transmission of knowledge on television. We are not in a classroom, so, for those who get lost, there is no chance to stop and ask. If someone indeed gets lost, he or she will switch to another channel.

In order to attain clarity, there are certain aspects that have to be taken into account: we must know and understand the content, the subject matter, what we are talking about, and

also the treatment, the way we are addressing it, without forgetting the spirit of the program, the premises, and the limits in order to convey it in the 27-minute slot we have. Then, the narrative and the language have to be simple, well ordered, plain, featuring repetition, if necessary, and assisted by examples and analogies in order to avoid, if possible, scientific terminology. Analogies, sometimes, must come in pairs. For instance, in order to explain what a telomere is in the documentary *Road to immortality*, we used two analogies: on the one hand, the ferrule (plastic tip) that holds the end of a shoestring, and on the other, a hair band[9]. We must make sure that the viewer understands what a telomere is because, otherwise, the program will not make sense at all.

Another important feature related to the problem of clarity is synthesis, and it is the popularizer's job to attain it, without fear of resorting to intervention, repeated questioning and summarizing.

Rhythm

Rhythm is key for any kind of narrative. The step outline, or beat sheet, is the document that summarizes the program structure in terms of time, thus marking the tempo on television. The step outline in *Tres14* aims for the viewer not to get tired or bored. Music (see below), math and intuition concerning time periods are essential.

The longest videos we feature are not longer than 6-7 minutes. Within the program structure, reports are alternated with very brief, assorted sections. We try to combine scientific content with anecdotes, tales, quotes, and other elements, in order to offer the viewer enough time, pauses, to digest, rest and return to pay attention. If we demand too much from the viewer, who is sitting on his or her couch while watching television at home, he or she might shift channels. Conversely, if we ask too little, he or she might abandon us as well due to sheer boredom. The key lies in finding the halfway point. Brief content, carefully sliced, helps the program go forward at a nice pace. Back in the 1980s, science television had an unhurried nature: long shots, slow pace, silences. Nowadays, audiovisual language has evolved toward the dizzy, and we cannot stay back, fall behind, yet we are not making music videos, for we need to bear in mind the viewer's understanding.

At the beginning of the program *Who am I?*, right after a voice over introduces the subject matter, we see all the people interviewed for this feature briefly answering a simple, short question: 'Where does our identity reside?'.[10] This is the introductory question for a program that will tackle the 'I'. The interviewees' answers point at the brain, the body and the environment, cells, DNA, proteins. And so, this tiny video clip sets the beat, introducing

9. *Camino a la inmortalidad* [*Road to immortality*]. Broadcasted on January 25, 2012. <http://www.rtve.es/alacarta/videos/otros-documentales/camino-inmortalidad/1303764/>, 10:07-11:00.

10. *¿Quién soy?* [*Who am I?*]. Broadcasted on April 8, 2012. <http://www.rtve.es/alacarta/videos/tres14/tres14-identidad/1230989/>, 02:30.

characters in a clear and naturalistic way, and helps the narrative just because of the fact that they do not agree. Discord is fundamental in television as it provides rhythm and interest. What works best in television is debate, discussion. Controversy is appealing. Unfortunately, we see it used in many programs in quite aggressive ways, such as in tabloid magazine programs and reality shows, yet it is a fact that disagreement is, in general terms, interesting to us, to the viewers, because it demands taking sides. However, science has to be portrayed as something solved, finished, as televised absolute truths. 'The expert says X', period. Scientists' doubts, debates, controversies and contradictions are hardly ever shown or talked about. But we know that science advances through questioning and disagreements, so, in my opinion, it is important to show it on television, for it generates debate, and debate is life, as doubt is very human. And, as abovementioned, the idea is to make a human program about science.

Beauty (and color)

"The communists used to say that color distracts spectators". This is a quote I remember from my college years. Not only television has also been defined all over as the opium of the people, but colors as well. Newspapers had to be published in black and white, for they had to be somber. In schools, they used to say, too, 'spare the rod and spoil the child', and as such it was carried out. In fact, British tabloids, the yellow press, were indeed published in yellow paper, as opposed to the serious, reliable white sheets for newspapers. Conversely, contemporary pedagogy explores and aims at teaching through playing and learning through joy. And science popularization revolves nowadays around these same grounds, that is, approaches of seduction. To popularize is to transmit, convey a specific knowledge to non-specialized viewers, the general public, a volunteer audience that will not ever have to pass a test about what is featured in a program. The suitable way seems to be the one that reaches a larger amount of viewers, and without beauty, the chance for seduction is really low.

In audiovisual terms, beauty is conveyed through images, sounds, voices and graphics. All these elements are important, and the higher level of beauty one can achieve by using them jointly, the higher the chance for the message to reach a wider audience, a larger amount of television sets. Spaces, locations where interviews are held are crucial, the colors featured in each shot, the quality and opportunity of the music, the soundtrack, the balance of graphics. The subject matter, raw, as just text, means nothing in audiovisual media, does not exist. For content includes everything, text, image and sound. Even though this seems too obvious, it is important to point it out, as, in scientific contexts, the text is deemed as the essential part of the content, while all the rest is considered as decoration.

Indeed, many programs have been and are done upon such premises, yet all those elements contribute to the content if there are the will and the knowledge to use them appropriately. A song, a given color, or a text, do not only transmit feelings, but also information

if we want to. The question of aesthetics is not banal, but crucial, because if we wish to seduce the viewers, we must battle against decades of boring scientists talking from non-existent or hidden locations, covered with dust, and surrounded by test tubes, as if they were 'entities' or gods. This is a valid approach to catch the attention of some elites that already have their own specialized channels. But it is useless, in my opinion, to catch viewers among the general public.

In other, somehow unorthodox, words, it is time to rescue science from unattractiveness. Offices and laboratories or studios with black backgrounds do not convey anything but darkness, and do not contribute a real dimension of the subjects scientists are conducting research about, nor a close view of the scientists either. Lab coats are not strictly necessary (plus they terribly reflect light, which makes shootings really difficult). To put it bluntly, scientists have also got legs and that only becomes clear when they are shown walking. *Tres14* prioritizes, whenever possible, casual clothing, ordinary human gestures, attitudes and activities, such as walking or having a cup of coffee, for scientists do not only think or work in front of computers, blackboards and microscopes (see below, *empathy*).

And sure enough, locations have to be in sync, contribute meaning in this same sense. For instance, the setting where an interview is held might convey much more information about the subject matter than a laboratory or and office. A cosmologist will transmit the unattainable if we situate him or her in the backdrop of a boundless landscape; a nutritionist, when in a market full of fruit, will seem very close and healthy to us; a neurologist in a strongly lighted environment would be quite possibly talking about connections and synapses, while if he or she is shot with a peaceful sky in the background, he or she will be most likely talking about the mysteries of the brain, thus suggesting a completely different mood.[11]

Music

On the other hand, music, the soundtrack, is one of the most powerful carriers of content in audiovisual media. It may warn the viewers about a danger, or predispose them to listen to something light or funny. Even the lyrics of a song may help the viewers introduce a subject.

In a recent program, we interviewed the orientalist philosopher and scientist Salvador Pániker.[12] We were talking about the origins of everything, something orientalists do not often mull over. The conversation led to the following statement: "In my deontological scales, if you put the universe, the big bang, all the galaxies and all we know about them on

11. An example of incorrect use of location: *Bebés* [*Babies*]. Broadcasted on September 27, 2009. <http://www.rtve.es/television/20090921/bebes-tres14-septiembre/293280.shtml>, around 07:00. And an example of correct use of location: Universo [Universe]. Broadcasted on February 7, 2011. <http://www.rtve.es/television/20110124/universo-tres14/397727.shtml>, 05:04.

12. <http://www.rtve.es/alacarta/videos/tres14/tres14-origen/2792796/>, 12:25 to 13:46.

one side, and Bach's fine-tuned clavichord on the other, Bach's clavichord will always win." Surely, he was referring to the connection human beings attain with art, in this case, music. There is no possible competitor. There is nothing else to explain. It just goes in.

Music is perhaps one of the best tools to work on the seduction of viewers. To caress, surprise, frighten, awaken, move or entertain the viewers. Indeed, the word 'audiovisual' starts with the voice 'audio' because words, sounds, come before paper, writing. Radio was also developed before television. And 'audio' refers to both talking and singing voices, to music and to sound effects. Diegetic care and use of music are not just reserved to cinema. For instance, most *Tres14* young viewers often inquire, through social networks, for the program's soundtrack. They appreciate the effort we make about it, enjoy it and comment (about) it to the point that we have decided to upload the track list of each program on the website. Music constitutes a connection that never fails, while contributing a lot of information, not only about the subject, but about the kind of program we are making (the spirit, as abovementioned), as well as about the viewers we seek. If we only play classical music, we would be introducing *Tres14* most likely as a slightly elitist program, focusing on intellectuals of a certain age. If, on the other hand, we only play the latest hits, it might as well become a program for young people exclusively. If, yet beyond, we only play experimental vanguards, we are quite possibly appealing to young elites. However, if we play all kinds of music, it will be an open and learned program. Not in vain, the music of the header and the logo constitute the image of the program, its seal, its business card. That is where the idea, the concept, the spirit, is synthesized. Sometimes, in fact, programs evolve, but not their headers, and so they become outmoded. The aim is to keep the signature, the theme music the viewer easily recognizes, yet, often, as time goes by, that cover becomes false. That is also the case of *Tres14*. The new season, starting in the fall of 2014, will feature new theme music and header, which will respond to the characteristics of the renewed program.

Empathy

Scientists are the characters of a science program, the actors, and their role, historically, is that of detachment. They have been portrayed as bearers of incomprehensible knowledge, busy people with no communication skills, conceited, and sometimes eccentric. In *Tres14*, in our search for human traits, we seek empathy, and do our best to depict scientists as equal with the viewers, that is, people that use the same language and codes, and whom the viewer can really understand.

This entails the use of a plain language, of analogies, and to dispense as much as possible with lab coats and traditional scientific gear. Empathy works in any kind of communication, including television. To see a scientist as somebody who may be living around the corner helps the viewers think that what he or she are about to tell is interesting and comprehensible. For instance, the program *Road to immortality* starts with a toddler on the screen and a voiceover stating: "This girl does not know that one day she will have to die,

but perhaps she will live healthy up to 120 years; this mouse has achieved so, his name is *Triple*." Then we see scientist María Blasco, without lab coat, laughing while she says: "*Triple*, we call him *Triple*, *the Triple*."[13] This is how we introduce María Blasco, molecular oncologist, researcher, collaborator of a Nobel Prize winner, and director of the National Center for Oncology. We introduce her with a laugh, and the viewers, instead of putting themselves on guard against a complex and serious content, immediately relax because they are positive they will understand what this woman (not seen as a scientist just yet) is about to tell them.

Poetry

The idea of *Tres14* is that science is part of the world around us. This opens up room for contextualization. Can we address science with poetry, literature or music? Or is science a parallel reality? In the current intellectual context in which Descartes' foundations are shaken by the threat of quantum physics, interdisciplinary trends, the combination of approaches to tackle anything, liquid reality, and orientalist influences that permeate from philosophy to medicine, to contextualize scientific content in relation to non-scientific disciplines, albeit human, does not seem too wild. Moreover, the use of literary references, music, or poetic perspectives, helps us present science as something else, something that coexists, something ultimately accessible to people that do not have any specific scientific training. In this sense, just the same that would occur with art, literature, poetry, cooking, do-it-yourself, or humor.

If we consider science as part of culture, why should we isolate it? If we consider science as a complex and difficult-to-convey content, why should we not resort to other, more enjoyable and known types of content? Many science programs include quotes from the world of literature and poetry. Most scientists in science programs use scientists' quotes. *Tres14* does it too, sometimes, scientists' quotes, but also writers', poets', artists'.

Yet, from my point of view, the use of poetry is not limited to the use of quotes. It is a matter of treatment, of designing a poetic treatment or perspective of subjects. The straightforward beauty of a given image, or of a piece of music, or of a few words, gives value to the scientific content, humanizes it. In addition, this gives respite to the viewers. Poetics establishes connections with the intellect, but above all with senses and emotions.

The program *The benefits of dirt* tackles bacteria's virtues. Considering that there are more bacteria in our body than (own) cells, it would seem interesting, at least, to try and tell their good side, their healing properties, and their importance in the origin and the development of life. By the end of the program, as an epilogue, an underwater video allows viewers to watch a girl's legs while she is floating in the water, kind of with the cadence of a placid

13. *Camino a la inmortalidad* [*Road to immortality*]. Broadcasted on January 25, 2012. <http://www.rtve.es/alacarta/videos/otros-documentales/camino-inmortalidad/1303764/>, 00:00-01:03.

music, a pop theme. A text is added: "Millions of bacteria and a girl swam in a blue swimming pool. Meanwhile, the sun was shining and Wilco's *Sky blue sky* was playing."[14]

The idea of closing programs with this kind of key is simple: to relax, to offer viewers a very simple and alluring final thought. In this case, the concept was that dirt is not so disturbing, it is part of life, and it even protects it. It is both the starting and final point of the program and can be conveyed in many ways: with a sentence, a formula, a declaration, with numbers and statistics, with graphs, or, certainly, with a poetic video clip. In this way, we try to connect with the viewers, not only with their brains. As I have said from the beginning and throughout the paper, we aim at making a program whose spirit leaves a human taste in the mouth.

Conclusion: on error

Mistakes are science's greatest enemies, but not television's. For a scientist, an incomplete explanation, oversimplifications, a misplaced comma, are surely mistakes. So they are on television, but not so much. Error has kept many sciences apart from the screens, popularizers' mistakes, misinterpretations that may damage a scientist's prestige. However, it is important to clarify and keep in mind that prestige is only harmed in scientific contexts. The popularizer's task is to try and avoid mistakes, but human beings make mistakes, and so, much more, journalists, because they work outside the scientific method, almost always without budget and lacking enough time.

With this in mind, scientist should ask themselves if it is better to risk mistakes or not getting anyone to talk about their research. Salvador Dalí once said that when someone harshly criticized him, he used to ask: "In how many lines?" The game in media is precisely to show up and get people talk, in our case, about science, so that science becomes important. This is risky, to be sure, but nobody is ever going to operate on anyone following the prescriptions given in a popular science program. Therefore, the risk is the tiniest.

The influx of information, nowadays, is so huge that not even error remains for an extended time, as it happens with correct information as well. In my opinion, from television, we can only hope for spreading interest, curiosity, perhaps through the transmission of very general ideas, given the ephemeral nature of the medium and the fierce competition. As an example, in a program about age, people's, animals', plants', the Universe's age, a voiceover talks about a song that was for a while in the top five of the British charts, yet it was strongly criticized by scientists because it stated that the Universe was 12 thousand million years old, as opposed to the widely held figure of 13.7 thousand million years,[15]

14. *Los beneficios de la suciedad* [*The benefits of dirt*]. Broadcasted on October 9, 2011. <http://www.rtve.es/television/20111004/beneficios-suciedad/465988.shtml>, 25:40.

15. *Edad* [*Age*]. Broadcasted on October 17, 2010. <http://www.rtve.es/television/20101011/tres14-aire/360073.shtml>, 06:51.

The lyrics were wrong, yet the age of the Universe and the stars was part of a big hit. In this sense, the popularizer's job is to give the viewers confidence, through work done within a team where he or she may suggest a plain language and analogies, and ask for examples. Simplicity is the best weapon, as abovementioned, to prevent error. In all, science is human, is alive, and that is how it should be depicted. In my view, to popularize is to seduce. I hope I have seduced all of you, or most of you, to read till here.

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SCIENCE ON TELEVISION: AUDIENCES, MARKETS AND AUTHORITY. SOME CONCLUSIONS

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In May 2013, the "7th European Spring School of History on Science and Popularization" took a closer look at the roles television and science have played, and still play in our daily lives. The aim of the School was to contribute to the analysis of television as a particular space where the complex relationship between science and its publics unfolds. It was an invitation to explore and experience television as a major constituent of the production, circulation and appropriation of scientific, medical and technological knowledge. Notwithstanding the sweeping expansion of the internet in the last two decades, people still build a highly significant part of the symbolic framework of the social, economic, political and cultural fabric around television.

Media and science are two sets of discourses and practices that play key roles in the construction and operation of contemporary societies. Science has been described as a form of communication (Secord, 2004; Topham, 2009), and media as a set of technology-mediated communication practices (Thompson, 1995; Couldry, 2004; Bräuchler & Postill,

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2010). The production and circulation of scientific-technological knowledge greatly depends on media. Correspondingly, media are, first and foremost, technology, an inescapable part of those processes of knowledge management.

We were interested in television communication practices from production and generation processes of formats and content to everyday domestic consumption patterns. As a whole, these practices are part of the way people appropiate technology and services in they everyday life. And they are also part of the way people communicate, eat, work, study, collaborate and solve problems. From this point of view, media practices and communication practices associated with the use and consumption of television can be understood as non-formal, multidimensional learning spaces.

In the conclusion of this dossier we shall try to identify some of the common themes the six articles deal with. We will start by addressing the tension between content and form in science popularization in general and in "Science on Television" in particular. We will then follow up with a joint consideration of audiences, the associated television (and science) practices and discourses, and the contingency of the historical contexts where science television takes (and has taken) place.

Does form beat content?

The question of form and content is as old as science popularization itself. It has been argued that "public science", i.e. the attempt to address society at large, was born in the early eighteenth century with the lecture courses on Newton's new physics (Stewart, 1992). Since those days popularisers have been faced with the thorny task to turn a more or less esoteric topic into something that may interest or better even fascinate the general public. Science communicators of all sorts, be they itinerant lecturers of experimental physics or school teachers, curators of museums or authors of popular science books, knew that they had to grasp the attention of their audiences first – through a heavy explosion, a ghost appearing on a screen or simply a gripping story – before they could teach them anything about chemistry, optics or zoology. In historical perspective, appealing to the senses, and particularly the eyes, was a prerequisite of any attempt to popularize (for the eighteenth century: Bensaude-Vincent & Blondel, 2008; for the nineteenth century: Kember, Plunkett & Sullivan, 2012; for the twentieth century: Nikolow & Schirrmacher, 2007).

Yet this "solution" brought along a "problem", that instantly threatened to undo the intended instruction. Numerous critics alleged already back in the eighteenth century that spectators of public demonstrations of natural phenomena will not learn anything. Any kind of information will get lost in the spectacle aimed at the senses of the audience – not at their mind. In short: the form will dispense with the content, or in the rhetoric of the critics, superficial entertainment will triumph over the subtleties of science. A short-hand for this tension is the opposition between the word (the scientific law, the equation, the formula etc.) and the visual (Galison, 2014). In three centuries of science popularization

and the continuous evolution of its media "Science on Television" may seem as the apex of this inherent tension between instruction and mere spectacle. TV is good at moving people, exciting us, making us laugh – in short: to entertain us. Yet due to its character as a visual medium TV maybe the form least suited to communicating science, as in one way or another all three practitioners of the School argued. Simplification, trivialization and worse, distortion are the accusations regularly levied against the attempts to popularize science, especially science on screen. In the words of Marcel LaFollette (2012: 229):

> The need to attract the largest possible audience pushed television's version of science, whether intended as education or fiction, even more toward sensationalism, politics, celebrities, and representation and away from the discussion of ideas, away from the real, away from attention to the thought and reasoning behind scientific conclusions and recommendations.

Yet at this point we have to take a step back and ask for the assumptions that underpin this kind of criticism. This view of science popularization considers communication as a one-way, top-down process. It assumes (and simultaneously legitimates) the authority of a minority of experts and the necessarily passive reception and acceptance of this knowledge by a purportedly ignorant general public. The very concern about strategies to engage audiences hints at an implicit acknowledgement of the agency of nonprofessionals in the construction of scientific knowledge. The underlying debate concerning scientific knowledge circulation and management refers to the (im)balance between information, education and entertainment (see, for instance: Collins, 1987; Shapin, 1992; McQuail, 1994; Irwin & Wynne, 1996; Bucchi, 1998; Rakow, 1999; Seale, 2004; Boon, 2008; Kirby, 2008; Nieto-Galan, 2011; Horst & Michael, 2011).

David Dugan, drawing on his long and successful career as producer and director of science documentaries, points to the variety of reactions of scientists: "Some despair at misconceptions and misinterpretations of data. Others are grateful that there is interest in their research at all and go out of their way to help." But more importantly Dugan notices a growing understanding on the part of the scientists for

> the need to engage the public in an entertaining, informative way […] To obtain funding, appreciation and sympathy for science, scientists realize they need to engage the public through mass media. In many institutions this is now part of their job description. … Nowadays, they are much more likely to appreciate the need to get across key messages and their chief concern is the lack of science coverage on television.

This disposition of the scientists to cooperate with the media or even to actively approach them, has been described as the "medialization" of science (Rödder, Franzen &

Weingart, 2012). In times of severe competition for public visibility collaboration with the media is more than an option for scientists, it has become a must.

The practitioner's toolbox

The challenge for the practitioner is to translate a potentially dry or even esoteric topic into entertaining and above all visually alluring narratives. Joan Úbeda puts it in terms of the disparities between distinct logics of communication (scientific versus journalistic/audio-visual). For him, as a director and producer of documentaries, it is very hard to narrate "facts" on TV while the medium is ideal to tell stories and to convey actions and emotions. And worse: "the scientific process is opaque to the camera". Dugan, also a producer and director of documentaries, speaks for Úbeda and many other practitioners when he proposes the following recipe: "first you tantalize the audience, then you intrigue them as the story evolves, and finally you resolve the story with a dramatic pay-off. This can be summarized in three steps: **tantalize, evolve, resolve**" (emphasis in the original) Ana Montserrat is in charge of a completely different television product, a 30-minute weekly program featuring short reports and news about science. She argues: "a program about science is just, and no less than, a television program, with strategies and rules that are common to other television genres. […] In the end, content has to be interesting and it has to look alluring."

Taken together the three contributions of Dugan, Montserrat and Úbeda provide a quite comprehensive "toolbox" of how to turn scientific content into a "televisable" format. To name but a few: a science program needs rhythm, clear explanations based on metaphors, analogies, visuals as well as a gripping narrative. Powerful images, to repeat the obvious, are paramount. The more relevant the topic is to the every-day-life of the audiences, their experiences but also their preoccupations, the better. To portray scientists as human beings, i.e. with passions and even mistakes, helps the viewer to empathize with them. Therefore scientific controversies may also lend themselves as a useful tool to communicate science on TV. From a "theoretical" point of view one might even think that such an approach could help to convey a more realistic image of science and how knowledge is produced. Yet once more form beats content: coverage of scientific controversies on television tends to focus on the personal battles between scientists rather than asking whether uncertainty might be inherent to the process of research. The toolbox seems quite an apt metaphor. Producers of science programs construct and form a very specific image of science according to the requirements of the medium.

(Re)searching the audience

Popular science is not only about instruction and entertainment, it is also a marketplace – and has been since the eighteenth century (Hochadel, 2007; Fyfe & Lightman, 2007). Any science communicator wants to reach a maximum audience. "Science on Television" might be the most blatant example of this need to capture the public. The reason is plain: TV is a

business perhaps more than anything else. This point was made time and again in the School. The viewing figures rule, more than anything else (quality, political relevance or other). Quantity is quality. It is all about market-shares, audience ratings and numbers of viewers. As Ana Montserrat put it: "This is not to say that anything goes in the name of audience ratings, yet the fact is that, without viewers, television does not make any sense." The acceptance or rejection of a given program, by simply staying or leaving a given channel, shapes decisively the ways science is depicted.

People actively appropriate the content offered to them on television according to their own worldviews, needs, preferences and fears, that is, their everyday-life experiences. People are not empty and passive receptacles to be filled with content. Rather, there is a dynamic relationship in which both, television professionals and their audiences contribute to shape the ways in which science, medicine and technology are presented. We may consider this as ultimately integrated and expanded consumer power around the rules of supply and demand. Its analysis is crucial for the understanding of contemporary processes of construction, circulation and management of techno-scientific knowledge.

Both practitioners and academics are interested in audiences, albeit in different ways. Scholars dealing with science popularization would love to know how the general public appropriates lectures, shows, books, exhibitions and other forms of science communication product in distinct historical contexts. But in most cases, even the mere reception (not to mention consumption patterns or dynamics of re-signification, see, for instance: Tabernero *et al.*, 2012, 2013) of audiences is elusive due to the lack of sources. In the case of "Science on Television" there are some indicators, though. An ever-refined system of rating provides data about who watches what kind of program. As it was pointed out at the School this information is only quantitative and rather questionable. Nevertheless the intriguing question remains how much these figures – unreliable as they may be – shape the decisions around the production and broadcasting of science content.

Research on patterns or determinants of production and broadcasting of science content (or even just reporting about science) in the media at large is far from commonplace. Even though interest in audiences' media content appropriation has a tradition as long as its production (Tabernero & Perdiguero, 2015), "the search for, and analysis of, several kinds of distortions in media representations of science have been leading topics of science-in-media research" in the last half century as Markus Lehmkuhl points out. This takes us back to the trivialization argument discussed above. For Lehmkuhl it is essential to stop looking exclusively at production matters. What seems crucial (also in historical perspective provided that primary sources allow for such studies) is to analyse the interplay between supply and demand.

The outcome of the international comparisons of Lehmkuhl and his colleagues seem dismal. It is hardly surprising that science is not a preferred subject for television viewers in general. Yet the reasons behind this may not be related to science itself: Lehmkuhl and his

colleagues "could not identify any motive, need or gratification that can be linked exclusively to science contents. Instead, expected and received gratifications [linked to entertainment, for example] appear to be applied to the medium TV rather than to specific nonfictional TV contents." In other words: even if we can name "motives of audiences to watch science programmes", these hardly help us to understand "the interaction between supply and demand of science contents in TV". In Lehmkuhl's analysis "edutainment" (as opposed to more traditional ways of popularizing science) has the greatest potential in European television because it may easily be adapted to well-established TV genres "such as the family show, the quiz show and even reality TV". Form (in this case genre) beats content yet again.

In terms of factual knowledge, viewers – then, now and in the future – may learn little about science if anything at all. Yet this is not the entire story. "Education" may not refer to what people actually learn by watching a news feature or a documentary. Historians of science and scholars of media studies ask what images of science and ideologies are conveyed through these formats (Apple & Apple, 1993; Haynes, 1994; Long & Steinke, 1996; Kirby, 2010; LaFollette, 2012). Science, medicine and technology often emerge as enormously powerful, albeit utterly enigmatic machineries that have the capacity to drastically transform the world and, incidentally, save our lives (science as commodity). Media products, given their production rules and constraints, do generally not question how these machineries actually function (science as process). Yet this does not prevent television to serve – at times – as a powerful tool for socio-cultural criticism, as we shall see.

The construction of authority

Comelles and Brigidi, from an anthropological standpoint, delve into the visual world of health, disease and medical processes offered by popular medical TV dramas. As medical anthropologists they highlight the ethnographic dimensions of series such as *E.R.*, *Grey's Anatomy,* or *Hospital Central*. In order to maintain the interest of the viewers it is crucial that they recognize themselves on the screen, that is to say "their personal or collective experience of doctors, nurses or hospitals". "Medical dramas intervene also in the cultural production of *ideal types* of professionals [and], institutions", according to Comelles and Brigidi. This kind of program may "represent the hegemonic conception of health, illness and care", but as the authors point out, also serves as criticism of the health system such as in the series *Bodies*.

We have seen the complexity of the processes of production of science content for television. We have also seen that it is not easy to grasp the highly diverse patterns of appropriation of the products as well as their broad socio-cultural impact. These analytical difficulties increase even more when both sides of the communication processes are analysed in isolation. Yes, "Science on Television" is a tough and elusive subject. But once more we would argue that the combination of different approaches we are proposing here is most

promising.[2] The sociological and the anthropological perspective need to be complemented by the historical one.

The historical perspective helps us to understand both, strategies of production of science programs and the socio-cultural context where patterns of appropriation of such programs were forged. Tim Boon's analysis of early British science television in the 1950s and 1960s brings the problem of how to create confidence and authority to the fore. He shows how the development of specific technologies and of narrative techniques of science television was inseparable from the characteristics of the medium. Although Boon's material and methodology are entirely different his results are very much in sync with the views of our three practitioners and with one of the main conclusions of Lehmkuhl's sociological approach mentioned above. As Boon puts it: "Such narrative demands about what makes 'good television' are clearly to do with conventions rather than with ideal categories."

And finally, he connects these aspects with the need in Cold War Britain (and, by extension, the rest of the Western World), to convey a sense of authority through the communication and portrayal of techno-scientific facts and processes:

> Television producers in the 1960s – not just in science television, but across all subject domains – were actively experimenting with these components of their new televisual language […] As they became fluent, the confidence and authority of television was made concrete. Caught like a fly in amber, particular authoritative articulations of the sciences […] also became established.

The examination of early television production strategies, such as the use of anchors, when "explored by a consideration of the sources of authority", reveals a fundamental correlation between the processes of construction of authority and the necessary appeal to people's everyday lives: "Science television achieves much of its cultural effect by the authority that the people in front of the camera project."

The dialogue continues

Our School wanted to build bridges between scholars studying communicative processes of "Science on Television" and producers of science content for television. In May 2013 practitioners and academics did meet: not only in a seminar room in Minorca but also in mind.

2. Actually, at the School, participants from different countries fleshed this impression out by sharing the nuances of our subject in their respective socio-cultural contexts. Comparative and *longue-durée* approaches were thus called for. Different case studies add up to an increasingly complex scenario. In this sense, "non-Western" participants contributed very different points of view. For future research, it might be highly revealing to include more than just "the West", and reflect more about Latin America, Asia, and Africa. For example in India, there are 400 TV channels and a high illiteracy rate among the viewers. Here "Science on Television" certainly takes on very different forms as compared to Europe.

All the speakers astutely reflected their own practices, the role they are playing and not least the binds they are in. The School felt like a real rapprochement between theory and practice.

Yet, turning the presentations into papers has led to a certain "de-rapprochement". Writing down what was said crystallizes positions clearer and brings basic assumptions out in the open. Reading the three papers of the practitioners suggests that the rules of the market entail a top-down view of scientific communication. This is a far cry from the picture drawn by historians of science trying to reconstruct the convoluted and "messy" process of producing knowledge. There are nuances. Dugan for example insists that audiences are far from ignorant and should be taken serious. This chimes with the "academic" claim that the general public is not a passive receiver.

Yet all in all the insights of history of science and of STS have so far not impinged on the views of many practitioners. Are the practitioners not aware of this research? This may not be the right question to ask. It seems that all these frameworks (the deconstruction of the deficit model, the co-production of knowledge, etc.) are not of practical interest for the practitioners. Yet this does by no means imply that practitioners lack theory. The practitioners present at the School and in this dossier theorize their own doing and know their "tool-box" inside out. Their three contributions add up to a "recipe book", full of examples of how to make science on TV attractive. As Ana Montserrat put it: "to popularize is to seduce". Practitioners are very apt in telling "good stories", even when they deal with "theory", with formulas of how to produce appealing TV content, as is the case in this dossier. We think it is no offence to the academics to state that the articles of the practitioners make for a much better read. Story telling is not our strong suit. It is an important object of study but not an actual practice for most academics. Easier said than done but there is certainly something to be learned from the practitioners, namely how to reach your audience with an engaging narrative.

Theory meets practice might thus mean exactly that: rapprochement and subsequent distancing; understanding and misunderstanding (what do we mean by "theory"?); acknowledging the differences yet learning from each other with respect to the necessity of a good story, the power of visual culture and the crucial role of the public. Dialogue is necessary but hardly ever easy – and never finished. The diversity of experiences and points of view in this dossier bears witness to an actual will of further communication and understanding. We need to think about the narrative strategies of our own craft in order to foster an enriching dialogue with media professionals and their productions – because there is indeed room for engagement.

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David Dugan is the Chief Executive Officer and co-founder (with Oliver Morse and Ian Duncan) of Windfall Films (1987). Before Windfall, Dugan spent ten years at BBC TV in the Science & Features Department, and a brief spell at NOVA in Boston. As a television producer and director, he has created many science series, most recently the BAFTA-winning *Inside Nature's Giants* (Channel 4, 2009). He also created and produced the Emmy-award-winning series *DNA* (2003), to mark the 50th anniversary of the double helix, which featured most of the key players in the history of this molecule. His numerous productions have been broadcasted on Channel 4, Discovery, the BBC, PBS, and NOVA. And his strong narrative approach to documentaries has won him many awards, including: Emmys, Royal Television Society Awards, Grierson Awards, Broadcast Awards, British Science Writers Awards and a BAFTA.

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RESSENYES

REVIEWS

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Astrid Kander, Paolo Malanima, Paul Warde, ***Power to the People: Energy in Europe over the Last Five Centuries***, Princeton and Oxford: Princeton University Press, 2013, ISBN 13: 978-0-691-14362-0 (HB) $ 39,50 / £ 27,95, x + 457 p.

Ningú no posa en dubte que la nostra societat no podria existir sense l'energia; però, ha estat sempre així? Quines han estat les diferents fonts emprades i com s'ha produït la transició de les unes a les altres? Ha estat el desenvolupament el que ens ha portat a incrementar el consum d'energia o ha estat a l'inrevés, i és la disponibilitat energètica la que ens ha facilitat el desenvolupament? I, finalment, com s'ha produït l'impacte de l'eficiència energètica sobre aquest desenvolupament?

Aquestes qüestions, tan profundament rellevants, són les que Astrid Kander, Paolo Malanima i Paul Warde tracten de respondre en el seu llibre *Power to the People*, una obra que estudia en clau d'història econòmica el paper que ha tingut l'energia al llarg dels segles com a motor fonamental del creixement econòmic europeu.

Aquest treball ha estat dividit en tres parts seguint la tradicional divisió econòmica en: 1) època premoderna (fins a 1800) (cap. III i IV), 2) primera revolució industrial (de 1800 a 1870) (cap. V, VI i VII) i, finalment, 3) segona i tercera revolució industrial (des de 1870 fins a l'actualitat) (cap. VIII, IX i X). Tres grans apartats que van precedits per la introducció (cap. I) i un capítol (cap. II) on els autors desenvolupen els termes teòrics emprats, i seguits per un darrer capítol (cap. XI) de sumari i predicció futura.

Fonamental per a poder comprendre tota l'anàlisi posterior, el capítol II comença per conceptes tan bàsics com la definició econòmica de l'energia que a partir de la definició física hi incorpora l'esforç i el cost. Segueix amb la distinció entre les fonts d'energia segons calgui transformar-les o no, tenint sempre present que el seu ús comporti un cost, obviant així aquelles que fossin gratuïtes. La productivitat energètica i la seva inversa, la intensitat energètica, els servirà com a mesura de l'eficiència econòmica de l'energia que els autors voldran

distingir clarament de l'eficiència energètica en termes termodinàmics. Però el concepte clau de l'anàlisi teòrica el constitueixen els blocs de desenvolupament, un terme introduït per Erik Dahmen (1916-2005) el 1950 i que tracta de reflectir la percepció de discontinuïtats en el desenvolupament a causa, entre d'altres, de l'energia. El creixement és estudiat, doncs, com un procés discontinu produït per innovacions tecnològiques que generen profundes transformacions en l'estructura del PIB. Es parla, doncs, de les macroinvencions responsables dels blocs de desenvolupament, però també de micro i de meso innovacions com a petites millores dinamitzadores, l'àmplia difusió de les quals pugui establir també els esmentats blocs. L'ampliació de la demanda a causa de la innovació o l'absorció del mercat a causa dels recursos complementaris esdevenen termes derivats, com també els de l'estalvi energètic que comporta el canvi tecnològic i l'expansió energètica que com a efecte rebot és generada per les noves aplicacions. Tots aquests termes porten els autors al debat sobre la desmaterialització de la producció com un indicatiu que les millores qualitatives porten cap a una economia de més serveis.

Paolo Malanima, professor d'història econòmica de la Universitat Magna Graecia, de Catanzaro (Itàlia), i president de l'European School for Training in Economic and Social Historical Research a la Universitat de Leiden (Holanda), ha estat l'encarregat d'estudiar el paper de l'energia en l'Europa preindustrial. Escassa energia i baixa productivitat van ser les característiques d'una economia on la base fonamental era l'agricultura i on les fonts energètiques –principalment la llenya, el farratge i l'alimentació, i molt residualment l'aigua i l'aire– anaven encaminades a sostenir majoritàriament les màquines biològiques encarregades del treball: els homes i els animals.

El clima, autèntic determinant d'un sistema agrari basat en els cereals, va marcar l'oferta i la demanda de l'energia anomenada vegetal que, majoritàriament obtinguda del conreu i les pastures, presentava una baixa productivitat energètica sols incrementable amb la productivitat de la terra i de la mà d'obra. Després de fer un balanç d'aquesta etapa històrica, el professor Malanima se centra en la transició energètica succeïda a la Gran Bretanya en el segle XVI que va portar a la superació de les limitacions de l'economia orgànica mitjançant el recurs del carbó, font que va permetre l'estalvi tant de la terra com del treball en substituir l'energia vegetal per la mecànica.

L'ascens del consum de carbó i la seva progressiva repercussió en la fi de l'economia orgànica és el tema amb què Paul Warde, lector d'història moderna de la Universitat East Anglia (Gran Bretanya), comença la segona part de *Power to the People*. Un consum energètic sense precedents basat en el consum de carbó va caracteritzar la primera revolució industrial que va modificar l'estructura econòmica convertint-la en més intensiva en capital i conseqüentment més productiva. El carbó, el vapor i els metalls van esdevenir els elements claus de la mecanització del tèxtil, base de la primera revolució industrial. El professor Warde considera que, tot i la seva importància, els preus baixos del carbó no foren determinants, sinó complementaris. Considera que el bloc de desenvolupament es va constituir al

voltant de dos nuclis d'innovació: la màquina de vapor i les noves tecnologies metal·lúrgiques, ambdues eminentment estalviadores de terra i de treball. L'elevat consum energètic i la disponibilitat de carbó foren les claus del creixement econòmic. Fou un camí, encetat a Gran Bretanya i al qual aviat s'hi afegiren altres països tot i que no de manera similar, que va donar lloc a una divisió internacional del treball en concordança amb els recursos, la tècnica i la demanda.

L'estudi del consum energètic del segle XX amb la irrupció del petroli i de l'electricitat, primer, i de les tecnologies de la informació i de la comunicació, després, és el tema d'estudi tractat per Astrid Kander, professora d'història econòmica de la School of Economics and Management de la Lund University (Suècia), en la tercera part del llibre. En primer lloc, se centra en el procés de transició del carbó a l'electricitat i al petroli i de l'expansió agrícola subsegüent arran de l'ús de fertilitzants. La professora Kander mostra com a poc a poc les fonts d'energia d'alta qualitat van anar reemplaçant les de qualitat inferior, millorant-se així l'eficiència energètica sobretot després de la Segona Guerra Mundial. I, tanmateix, com en la primera revolució industrial en la segona també es va continuar fent dependre el creixement econòmic de fonts majoritàriament fòssils.

Dos blocs de desenvolupament, un sobre el petroli i l'altre sobre l'electricitat, que permeten interpretar els canvis succeïts, principals responsables del creixement energètic, fins a la dècada de 1970 quan un nou règim vinculat a un nou bloc estabilitzarà el consum d'energia. El bloc del petroli amb el motor de combustió interna com a nucli serveix a la professora Kander per a explicar com la demanda de gasolina entre 1910 i 1950 va exercir de força motriu per a la transició del carbó al petroli en un context de mercat d'absorció, i com posteriorment l'abaratiment d'aquesta font va impulsar la revolució del transport en forma de mercat d'ampliació. Quan es va produir la substitució de la màquina de vapor pel motor, va prevaldre l'estalvi d'energia, però amb l'increment del transport es va imposar l'expansió energètica tot i les millores en l'eficiència dels enginys.

En canvi, en el bloc de desenvolupament de l'electricitat, a una primera fase de substitució d'altres fonts tant en l'enllumenat com en usos tèrmics, típica del mercat d'absorció, la va seguir una segona fase de mercat d'ampliació a causa de les aplicacions d'aquesta font a diverses infraestructures i indústries. Tanmateix, l'electricitat ha mostrat sempre una clara tendència a l'estalvi energètic, generant considerables millores en la productivitat que segons l'autor no es detecten en el petroli. Ara bé, en produir estalvi, també estimulava el creixement i donava lloc a una significativa expansió energètica com a efecte rebot.

En entrar en escena la microelectrònica i el desenvolupament de les tecnologies de la informació i de la comunicació (TIC), el consum s'estabilitza i un nou règim energètic entra en escena produint-se la tercera revolució industrial. El semiconductor com a nucli va iniciar un complex conjunt d'innovacions que afectaren el control elèctric, els ordinadors i la microelectrònica, que va tenir gran repercussió en obrir el coneixement a tots els usuaris modificant la seva funció principalment en l'ensenyament. Aquest bloc de desenvolupa-

ment mostra tendències més clares cap a l'estalvi que els que el precediren, tot i que com sempre aquest estalvi es veu qüestionat per l'estímul al consum que porta aparellat.

Detectats els paral·lelismes i les diferències entre els blocs de desenvolupament, així com el diferent grau de repercussió en l'expansió i l'estalvi energètic, la professora Kander cerca les raons de la millora energètica de la dècada de 1970, quan l'expansió del sector serveis transforma la societat cap a una etapa presentada com d'economia desmaterialitzada. L'externalització de la producció industrial cap a zones menys desenvolupades i una nova divisió del treball en un món globalitzat marquen el futur d'aquest nou règim postindustrial.

Ens trobem davant d'un treball excel·lent no sols perquè respon les preguntes plantejades inicialment, sinó perquè a més s'aventura a fer prediccions. El text proposa algunes consideracions de cara al futur sobre la viabilitat de l'economia ecològica o sobre l'orientació dels canvis energètics necessaris agafant com a base les lliçons extretes de les etapes històriques anteriors. El coneixement de les característiques dels blocs de desenvolupament, de l'estalvi i de l'efecte rebot que solen generar, serveix als autors per a clarificar com les polítiques de mercat determinen o frenen la implantació de les innovacions tecnològiques i, en definitiva, com es produeix el desenvolupament econòmic. Consegüentment, podem afirmar que *Power to the People* és una obra recomanable no sols per als historiadors de l'economia o de la història de la tècnica, sinó per a tot aquell que estigui sensibilitzat i preocupat pel futur de la humanitat.

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Juan Navarro Loidi, ***Don Pedro Giannini o las matemáticas de los artilleros del siglo xviii***, Segovia: Biblioteca de Ciencia y Artillería. 2013, ISBN 13: 978-8493577179 701 p.

El llibre de referència de Navarro Loidi tracta d'una temàtica molt important en la Història de la Ciència i la Tecnologia, l'ensenyament dels oficials d'artilleria en el segle xviii a Espanya. Centrat en Pedro Giannini (1740-1810), primer professor del Reial Col·legi de Cavallers Cadets d'Artilleria de Segòvia (inaugurat el 1764 i tancat el 1808), l'autor descriu de forma acurada, completa i crítica el contingut dels textos matemàtics emprats en l'ensenyament en aquest Col·legi. Es fa una anàlisi detallada del contingut emfasitzant el rol crucial de les matemàtiques en l'ensenyament dels oficials d'artilleria. Navarro Loidi és un gran i experimentat historiador de les matemàtiques que ha focalitzat la seva recerca sobre les ciències militars en el segle xviii. Així doncs, a través del llibre no oblida el context històric i la rellevància de les discussions en el Col·legi sobre el contingut matemàtic més adequat per a ensenyar als oficials d'artilleria, ja sigui teòricament o pràcticament.

El llibre té 701 pàgines i consta d'onze capítols seguits d'una llista de textos de Giannini i una extensiva i completa bibliografia separada en manuscrits i obra impresa. Comença el llibre amb una breu panoràmica de l'ensenyament de les matemàtiques i les ciències militars a Espanya durant el segle xviii fins a l'obertura del Col·legi d'Artilleria de Segòvia. Navarro Loidi presenta un resum d'allò que s'estudiava a l'Acadèmia de Matemàtiques de Barcelona a l'època de Mateo Calabro i a la de Pedro Lucuce; també fa referències a les matemàtiques ensenyades a l'Acadèmia de Guàrdies Marines de Cadis, i a les propostes fetes per la Societat Matemàtica Militar de Madrid. La part més original és la que tracta de l'ensenyament dels oficials d'artilleria a les Acadèmies obertes el 1722 i el 1751, així com les pàgines dedicades als tractats de pirotècnia, publicats per autors cultes o per artillers pràctics en el període 1700-1764. En el segon capítol, Navarro Loidi descriu l'ober-

tura del nou Col·legi de Cavallers Cadets d'Artilleria el 1764 i el seu funcionament, fins a l'arribada de Giannini. En el tercer capítol es donen molts detalls de la vida de Giannini, matemàtic al qual està dedicat el llibre. Aquí Navarro Loidi comenta la carta que Giannini va escriure a Campomanes, arrel de les matèries que es devien estudiar en un curs de matemàtiques, que va publicar Rubin de Celis en el pròleg de la seva traducció a *Historia de los progresos del entendimiento humano en las Ciencias Exactas* (1775), de Saverien. La carta mostra que Giannini estava al dia dels últims avenços en matemàtiques a Europa. De fet, proposa incloure en el curs obres d'autors com ara els anglesos Barrow, Simpson o Smith (per a l'òptica), els italians Grandi i Agnesi, els francesos La Caille i Clairaut i l'espanyol Jorge Juan (per a la mecànica). Navarro Loidi també explica l'impacte que van tenir les publicacions de Giannini a l'estranger, fins al 1790 aproximadament, quan van ser ressenyades a la revista francesa *Journal des Savants*, en diverses revistes italianes i en algunes d'angleses i alemanyes.

Els capítols 4, 5, 6, 7, 8 i 9 constitueixen la contribució més important del llibre. En aquests capítols Navarro Loidi detalla acuradament el contingut científic dels treballs de Giannini: els quatre volums del *Curso Matemático para la enseñanza de los Caballeros Cadetes del Real Colegio Militar de Artilleria* (1779-1803), que Giannini va escriure per a les seves classes al Reial Col·legi d'Artilleria, explicats als capítols 5, 6, 8 i 9; el llibre *Prácticas de Geometría y Trigonometría*, també emprat a l'ensenyament i explicat al capítol 7, i dos treballs de recerca que tracten diferents temàtiques, explicats al capítol 4. L'autor descriu els mètodes, les fonts i les interpretacions de les obres de Giannini a través d'un considerable nombre de referències i il·lustracions. Són de particular interès les seccions en les quals Navarro Loidi compara les explicacions de Giannini amb les que estan incloses sobre aquests temes en els tractats d'altres autors, particularment en l'obra *Elementos de matemáticas*, de Bails (1779-1804), en *Cours de mathématiques à l'usage du Corps Royal de l'Artillerie*, de Bézout (1770-1772), i en *Compendio Matemático*, de Tosca (1707-1715). El primer volum del *Curso Matemático* de Giannini tracta de geometria clàssica i està explicat per Navarro Loidi en el capítol 5. La primera part és la més llarga i consisteix en una versió dels *Elements* d'Euclides. Giannini presenta, com era usual en l'època, els llibres de l'I al VI, l'XI i el XII d'aquesta obra, amb el rigor de la versió original, però fent algunes concessions a les matemàtiques d'aquell temps. Per exemple, Giannini emprava símbols algebraics per a facilitar les seves explicacions. La segona part conté elements de trigonometria, mentre que l'última part del primer volum està dedicada a les còniques. En el capítol 6, Navarro Loidi descriu el contingut del segon volum del *Curso Matemático* de Giannini que tracta d'àlgebra, amb diverses citacions i imatges; l'algorisme de les quantitats numèriques i literals i els logaritmes a la primera part, les equacions i les seves construccions geomètriques a la segona part, i conclou amb l'ús de l'aritmètica universal per a solucionar una col·lecció de problemes aritmètics i geomètrics. Navarro Loidi assenyala que en el pròleg Giannini diu haver escrit aquest volum utilitzant «estas teorías tratadas en los mejores Cursos de Álgebra compuestos por los señores New-

ton, Pedro de Martino, Clairaut, Mac Laurin, Saunderson, P. Reineau, Wolf, Doña Cayetana Agnesi, Vicente Riccati y Geronimo Saladini, Simpson, Bezout, Bossut, Leonardo Euler, abate Sauri, Caravelli y otros...» (p. 381-383). Abans de continuar amb el seu *Curso Matemático*, Giannini va publicar l'obra *Prácticas de Geometría y Trigonometría* (Segovia, Espinosa, 1784) que complementava i donava una utilitat pràctica als dos volums ja editats. Aquesta obra, que consta de cinc llibres, està explicada en el capítol 7. La part principal del primer llibre és sobre instruments, mentre que en el segon llibre s'estudia la forma de mesurar angles i distàncies, amb l'ajuda d'aquests instruments. El tercer llibre analitza com dibuixar plànols i mesurar superfícies; en el quart, els mètodes per a mesurar volums, i en l'últim, l'anivellació de l'aigua. Navarro Loidi mostra que Giannini, a més de ser un matemàtic rigorós partidari dels mètodes geomètrics dels grecs i del càlcul diferencial, era també un bon geòmetra pràctic. El tercer volum del *Curso Matemático*, que consta de quatre parts, tracta del càlcul diferencial i integral i està explicat en el capítol 8. A la primera part s'estudien els fonaments del càlcul diferencial i les diferencials de les expressions algèbriques, logarítmiques, exponencials i trigonomètriques, juntament amb les integrals immediates. A continuació es defineixen les diferencials segones i terceres, s'introdueixen els diferencials d'arc i els elements d'àrea, en coordenades cartesianes i polars, i s'apliquen a trobar la longitud d'alguns arcs i la superfície de diverses figures. Finalment s'estudien les tangents, subtangents, normals, subnormals, radis de curvatura, evolutes, màxims i mínims, i asímptotes de les corbes. La segona part és més curta i estudia la integració d'expressions diferencials amb una sola incògnita de tipus racional o irracional. La tercera part tracta de la integració d'expressions que contenen dues o més variables i les seves diferencials de primer ordre, explicant els mètodes de resolució d'equacions diferencials de Johan Bernoulli i de Jacopo Riccati. En el llibre quart s'estudien les equacions diferencials de segon ordre o d'ordres superiors, i es resolen alguns casos particulars, citant diverses vegades els treballs de Vicenzo Riccati. Navarro Loidi fa referència en aquest capítol als apunts que el cadet Tomàs Eslava va prendre a classe l'any 1781, per saber què es va ensenyar realment al Col·legi de Segòvia del que conté aquest volum del *Curso Matemático*. El capítol 9 tracta de l'últim volum del *Curso Matemático* que està dedicat íntegrament a la mecànica i consta de tres parts: estàtica, hidrostàtica i dinàmica. Navarro Loidi descriu aquest contingut acuradament i emfasitza que en aquest volum s'utilitza freqüentment el terme «el mètode de les accions», introduït per Johan Bernoulli. A la secció d'hidrostàtica l'autor explica que Giannini detalla els aparells que s'utilitzaven per a estudiar els gasos, com el baròmetre, el termòmetre i la màquina pneumàtica, i les màquines per a extreure aigua, incloent-ne una en què s'utilitza la calor. La tercera part, sobre dinàmica, és la més extensa i complicada de les tres parts. Aquí Giannini analitza matemàticament el moviment uniforme, el moviment uniformement accelerat, el moviment compost i el moviment dels cossos pesats. A continuació es tracta dels pèndols, i de les corbes tautòcrona, isòcrona i braquistòcrona. Navarro Loidi fa notar que tot l'estudi es fa matemàticament, i sense aplicacions pràctiques, ni exemples

numèrics o comparacions amb els resultats experimentals. De nou l'autor compara aquest contingut amb les notes de classe d'Eslava. En l'últim apartat Navarro Loidi argumenta les raons per les quals aquest llibre va tenir tan poca fama a Espanya.

En el capítol 10, Navarro Loidi tracta de les discussions que hi va haver sobre el programa d'estudis del Col·legi, i en particular sobre el paper exercit per les matemàtiques en la formació dels artillers. L'autor comenta el debat que es va produir en el Consell Escolar del Col·legi a començament de 1782, analitzant les postures de cadascuna de les parts i la decisió final, majorment favorable a Giannini i a un programa d'ensenyament exigent en matemàtiques per al Col·legi. En el capítol final del llibre, Navarro Loidi, a fi de completar el coneixement dels ensenyaments del Col·legi, ens aporta els resums de les biografies d'uns cinquanta artillers que van ser professors del Col·legi de Segòvia des de la seva fundació, el 1764, fins al seu tancament, el 1808. Alguns són personatges ben coneguts en la història de la ciència com Juan M. Munárriz o Vicente Alcalá Galiano, mentre d'altres van ser famosos militars com Tomás Morla o Pedro Velarde. Amb aquest conjunt de biografies l'autor mostra que els ensenyaments del Col·legi van servir per a transformar la formació dels artillers espanyols, fent les classes més científiques i fent que els estudiants fossin més capaços d'entendre els avenços produïts en l'artilleria, així com de dirigir les fàbriques d'armament que van passar a dependre del cos militar.

El llibre és molt valuós tant per la novetat d'aquestes biografies com per un considerable nombre de noves informacions de l'època; tanmateix, podríem dir que la contribució més rellevant d'aquesta publicació és que proporciona als historiadors de la ciència i la tecnologia un profund i complet coneixement de les matemàtiques i la mecànica que estaven circulant en el segle XVIII a Espanya. Aquesta contribució és també molt significant per als que investiguem sobre la difusió i l'apropiació de les novetats de la matemàtica europea del segle XVIII per part dels autors espanyols.

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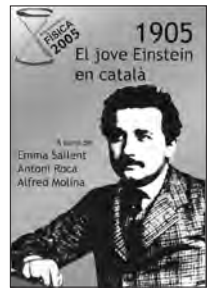

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