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Short communication

Communicating science: The making of a comics poster on biodeterioration

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ABSTRACT

The History of Humanity can be traced by our Cultural Heritage. However, we are not the only ones who can appreciate our tangible legacies. Biodeterioration is well recognized in the field of cultural heritage conservation. Over the last few decades, it has been the object of both modest and ambitious studies, some aiming to identify one single agent, others trying to understand entire communities. Proper sampling and tools such as culture-dependent techniques, DNA analysis, protein and pigment identification studies, metabolomics and microscopy (in its various forms) are important allies and their combined results should be prized for the valuable data they provide. Coordinated efforts to implement standard practices and share relevant information and approved guidelines to better understand any cause-effect relationships are vital to address this issue.

In an international symposium devoted to biodeterioration, the paragraph above is regarded as common sense and a poster on the topic would hardly deserve a second look. Comics have shown to deliver scientific information with accuracy and a higher impact as they are seen as lighter and more enjoyable to look at and read than the same amount of information delivered as a text form or even in graphics. Next is the detailed making of a comics poster intended to appeal to the attending public while also displaying accurate scientific context.

Science communication is of the utmost importance in every researcher's life. Its relevance rivals research itself as uncommunicated science is also non-existing science. It is also important to pass our points across since science affects our everyday lives but general population is still lacking in interest and the internet has assumed a role as an informal educator much due to its interactivity and animated contents (Lin et al., 2015; Farinella, 2018). It has, therefore, become increasingly important to devise new forms to raise awareness and reach larger crowds be it for fundraising purposes, to justify research to society (Friesen et al., 2018) or even attract otherwise unengaged individuals with no particular interest in a given subject (Farinella, 2018). And science communicators are expected to do this without submitting the reader to long texts and tedious data but also without losing focus on the scientific details needed to get through to the public.

Scientific journals have, for some time now, encouraged authors to submit videos and other non-text formats along their conventional article submission, an effort which can lead to more detailed information and simpler and quicker forms to understand the contents of the text-only article. A recent journal, JoVE or Journal of Visual Experiments publishes videos alongside short papers in order for others to visualize laboratory experiments, which greatly facilitates the understanding and efficient reproduction of both basic and complex experimental techniques (Tatalovic, 2009; Friesen et al., 2018).

There is room for both forms of communication – the detailed and directed at the experts and the more relaxed for a quick grasp on the subject or for the general public.

Comics are defined as 'a narrative form consisting of pictures arranged in sequence' (Lin et al., 2015) and 'science comics refer to a medium using a humorous illustrated narrative to transmit scientific information' (Lin et al., 2015) or, as Tatalovic (2009) puts it: "comics, which have as one of their main aims to communicate science or to educate the reader about some non-fictional, scientific concept or theme". So, there are two very important features to be discussed in comics: the illustration and the narrative. Illustrations have always played a significant role in scientific writing and communication (Farinella, 2018) as text-like information displayed alongside pictures is more easily understood, retained and later retrieved from our memory (Lin et al., 2015; Farinella, 2018). This however, depends on the reader's

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level of expertise, sometimes vital to fully grasp and associate the picture with the text. Combining illustrations with a narrative may help hamper this problem as text and images in comics are more closely associated and connected than those in books (Tatalovic, 2009). Comics also divide the information into panels, easing the reading experience and stressing relevant information such as parts and processes (Farinella, 2018).

As narrative forms have been suggested by several authors (Negrete, 2013; Farinella, 2018) to be an excellent form of communication, comics - a narrative genre consisting of pictures and words (Lin et al., 2015) - are conceivably one of the best methods to deliver scientific information as they bring humor and enjoyment which, in turn, attracts people's attention (Tatalovic, 2009; Lin et al., 2015).

Humor plays a definite role in the comics success stories but its use in science does not come without perils. According to Tatalovic (2009), impressive artwork and witty interactions between the characters may tempt the authors to disregard scientific accuracy and this a significant risk which demands close surveillance while producing the comics. The risk of imprecisions and the way these are apprehended by the reader are certainly some of the questions addressed when evaluating the effects of comics in science communication.

Is there room for comics in a scientific congress or symposium? The last decades have witnessed a large increase in the use of comics as a form of communicating to different age groups and cultural backgrounds (Farinella, 2018). There are already some published examples of comics being applied to science communication and a very good review on the topic (Tatalovic, 2009). We took the opportunity to test the acceptance of a poster on cultural heritage biodeterioration even if the public was highly knowledgeable on the field. The poster presentation seems to fit the genre since it is, by definition, more relaxed than the scientific article, even if just for the fact that appearance and space use must be used wisely in order to provide fundamental information without tiring the reader with too many details.

The effectiveness of the message transmitted by this form of communication is a relevant point to consider. Despite comics' quick dissemination, the impact of science comics is still relatively unknown as empirical research remains scarce (Lin et al., 2015; Farinella, 2018). The first attempts were performed at classroom settings and the results showed that, as far as knowledge acquisition was concerned, comics were dependably more effective, basically because they were better at engaging and sustaining interest from the students (Farinella, 2018) Outside the scope of the teaching class, Lin et al. (2015) performed an assessment on the impact of comics on delivering scientific contents on nanotechnology. The qualitative evaluation by the readers described the textual information provided to the subjects as "boring", "difficult to understand", "time-consuming", and filled with professional terms, while the comics were labelled as engaging and interesting to the point that reading them repeatedly would not be a bother. They were also classified as lively, empathetic and easy to understand. Sixty per cent of the contents of the comics book were, in fact, apprehended by the lay readers in this study. According to the quantitative impact measures applied in this study, the comic book "significantly promoted laypeople's knowledge of attitudes towards nanotechnology as did the text booklet", but appeared to add to the joy of learning and interest, a strong indicator of the importance of the positive emotional and intrinsic motivation comics can provide. As previous studies have indicated, humor plays a significant role in this effect (Lin et al., 2015).

Both the classroom study and the assessment performed by Lin et al., (2015) reached the conclusion that text equals comics when it comes to memorization, but to engage an occasional reader, comics perform much better (Farinella, 2018).

The poster "Wanted Dead and Alive" focuses on the action fungi can have on cultural heritage and the problems scientists and conservators still experience when attempting to identify them in order to diminish or reverse their impact. Fungi are known to induce chemical deterioration, staining and discoloration, including foxing and also physical decay and mechanical stress (Hastrup et al., 2011; Bergadi et al., 2014; Sequeira et al., 2017a; Melo et al., 2019). In addition to all these deterioration effects, handling mould contaminated objects can constitute a serious health risk, as many of these microorganisms can be pathogenic/toxinogenic (Bennett and Klich, 2003; Pinheiro et al., 2011). Even when the fungi are already inactive, their fungal structures can still contain active allergenic and toxic compounds to humans (Florian, 2002, p. 57).

Superficial fungal dry conidia in bulk can be easily removed by simple vacuuming the affected areas, but in order to reverse the stains formed by secretion of pigment into the substrate, the fungi itself and the solubility of the given pigment should be addressed (Unković et al., 2018). Different fungal species have shown varying susceptibility to antifungal treatments (da Silva et al., 2006; Sequeira et al., 2017a, 2017b). Besides, the material deteriorating and pathogenic/toxinogenic potential of fungi, have also shown to vary with species (Adan and Samson, 2011; Pinheiro et al., 2019). Therefore, determining exactly which fungi are dwelling on our cultural heritage has always been a matter of interest (Miller and Sa, 2012; Coutinho et al., 2013; Piñar et al., 2015a; Paiva et al., 2019; Sequeira et al., 2019).

Regardless of the identification method used, does a positive identification mean the fungus is the actual culprit for the alteration? Not really. We may very well be jumping the gun on identifying the real culprit because, much like in real life, without proper evidence, we are possibly condemning possible bystanders and letting the real cultural damaging microorganisms get away with *"crime"*.

Sampling procedures and laboratory techniques are directly related to this bias. From the initial studies to modern day practices, identification methods have suffered a significant shift from classic morphology identification to DNA manipulation, in all its current and ever-changing forms and advances (Pinheiro et al., 2019).

The very important issue of viability of the fungal flora is why conventional methods are still used and when it comes to assessing fungal communities this method is said to recover 70% of the elements present in environmental samples (Sanmartín et al., 2018). It is a time-consuming method and demands an experienced eye but is also cheap and allows to study the chemical implications of the retrieved fungus. However, because it is based on the viability of the community sampled, it disregards all former and possibly existing elements which can be now dead or for which we have not provided the conditions needed to grow in culture. The use of DNA based methods comes to fill in the gaps as they are able to detect both live and dead elements, provided an efficient DNA extraction, amplification and identification method is applied. DGGE has been largely adopted in most of the studies involving cultural heritage biodeterioration by fungi (Schabereiter-Gurtner et al., 2001; Michaelsen et al., 2009, 2010). Fungi like *Chaetomium murorum*, *Myxotrichum deflexum* and *Trichoderma longibrachiatum* found on paper-based altered documents have only been identified in these sometimes very challenging samples through molecular biology (Pinheiro et al., 2019).

However, ~~this~~ and other DNA related studies offer no information on the (in)activity of a possible causative deteriogen species. Working with nucleic acids is also still expensive, in both reagents and devices needed, and it demands technical expertise.

Next-generation sequencing is a relatively new but quickly wide spreading method (Chimienti et al., 2016; Li et al., 2016; Kraková et al., 2018; Szulc et al., 2018) which aims at delivering a full scope on the communities thriving in a given sample. So, problem solved? Not really, at least not yet, because even though this metagenomic analysis provides a fast and exhaustive identification of the present microorganisms, the operational taxonomic units (OTUs) are obtained with a 97% maximum similarity, which only allows for a reliable identification to the genera level. And although we can understand the vast amounts of data delivered by this method doubts remain on what to conclude from them. Complementary methods can be used to help solve the puzzle. Exploring the biodeteriorated areas in search for microbial cells is a method already performed by a few recent studies (Piñar et al., 2015b; Sequeira et al., 2019) but it can be a daunting task to try and identify ~~the~~ fungus

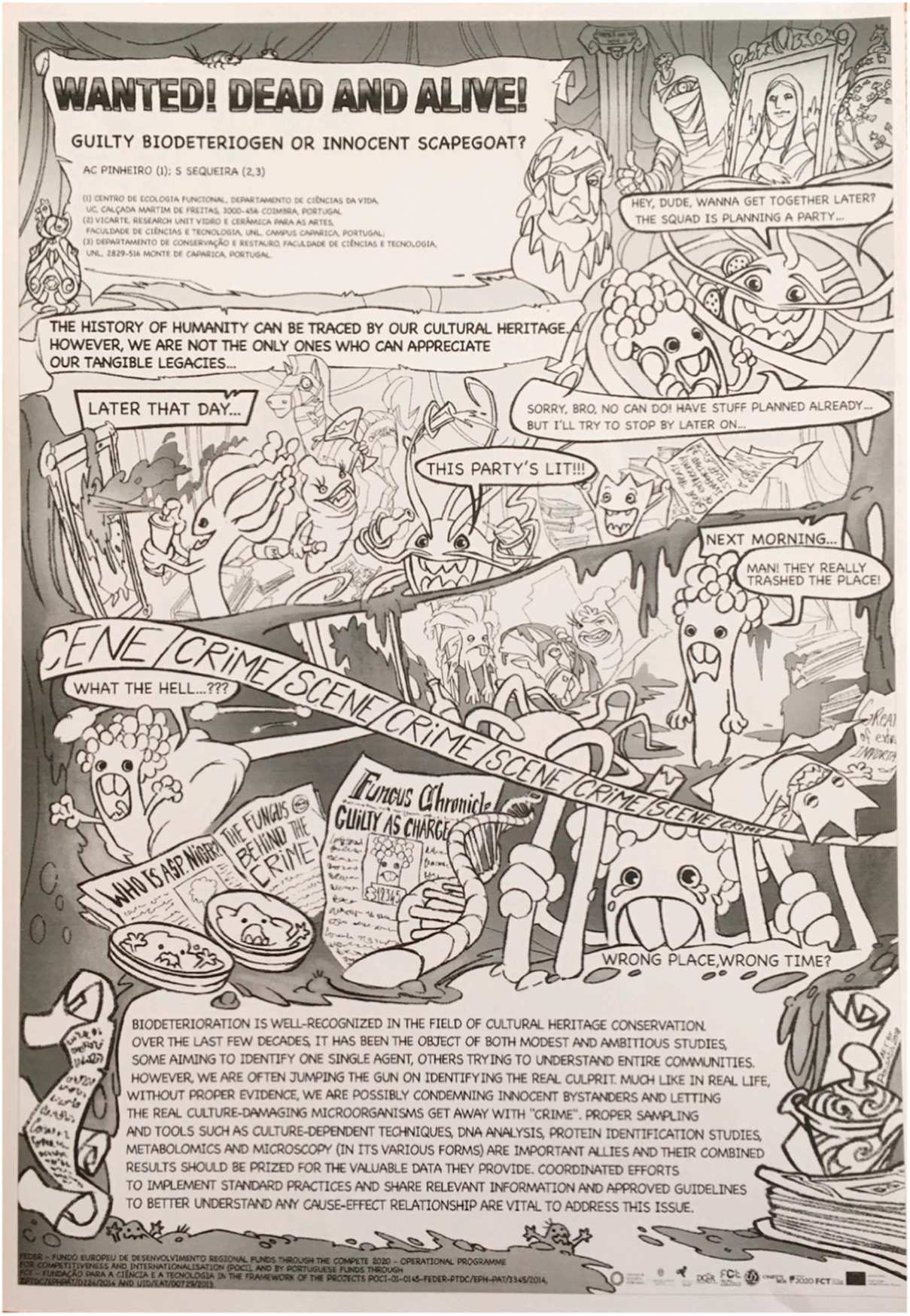

Fig. 1. Poster presented at the IBBS 18 New Trends in Biodeterioration of Cultural Heritage, Coimbra, 2018. Artwork by Raimundo Pousada.

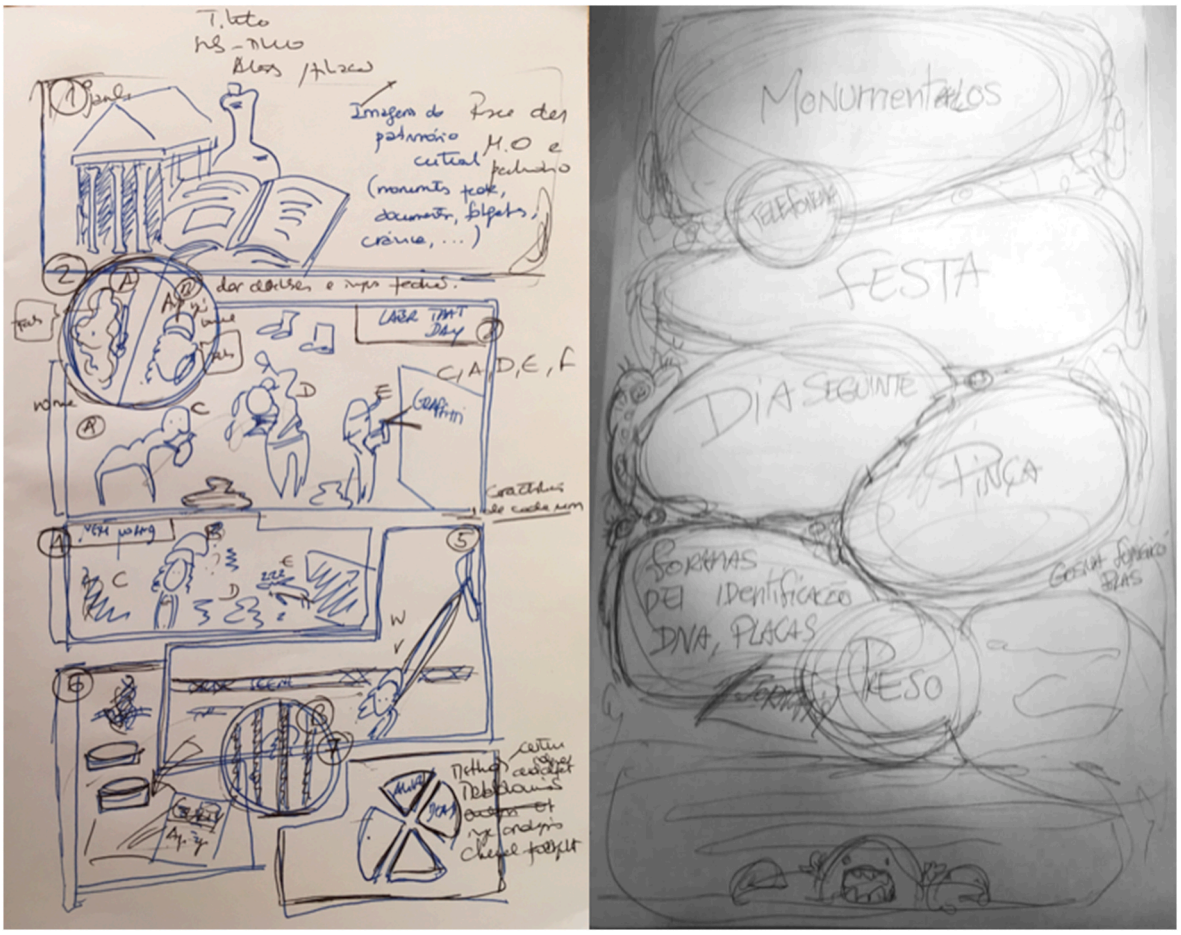

Fig. 2. a and b – On the left is the scientific first sketch and on the right is the artist's placement of the scenes as they would be better read by the viewers.

using solely microscopy. Pigment solubility is not always determined in practice but a pigment secretion assay in combination with the aforementioned strategies could provide the information needed to dismiss unspecific and possibly aggressive cleaning methods (Unković et al., 2018). This, of course, applies not only to paper-based heritage but to all cultural heritage materials susceptible to biodeterioration.

So, whatever the method of choice to identify the fungus and for the time being, precaution is mandatory when assigning a culprit for a given alteration and this was the idea we intended to deliver using comics in a large poster format.

The scientific context given above is not particularly complex to the accustomed reader but can be extremely hard to translate to the artist responsible for the poster design. On the other hand, designing the comics comes with unsuspected complexity on its own.

As Friesen et al. (2018) explain, creating the comics: "*The rise of the incredible salty Salicornia power plant"* demanded a detailed storyboard which helps get the idea across to the artist while also defining the general structure of the final result. As happened with the Salicornia superhero comics, we also used Google images as a source to create an image database and inspire the artist. The authors reviewed data from over 70 studies and information was collected on the most common fungi and methods used to detect them (Pinheiro et al., 2019).

Given their frequency, the fungi most *most likely* associated with noticed visual damage are among the several items presented in the poster, such as *Aspergillus* sp. and *Penicillium* sp., with their characteristic fruiting bodies, *Chaetomium* sp, with its long "hair". On the methods of detection, the DNA structure (for the molecular biology protocols) and the Petri dishes (for the classic culturing methods) are also present.

The text part was also defined and positioned, both the large text boxes with the scientific explanation and the text presented as bubbles or headers. Fig. 2 presents two of the first drafts for the poster.

At this point, among other important technical details, the artist was especially relevant in underlining the importance of placing each scene correctly and how a mistake in these initial steps renders the flow of the story completely inaccurate.

Deciding on the characters' features is also pivotal since they play a central role in literary narratives. The option of creating dynamic and anthropomorphic characters adds to their relatability and allows a broader audience to identify with the story and contents (Farinella, 2018). Curiously, more and more online programs directed at creating comics are available to the general public, but these tend to be very generic in the characters they provide. The specific images and concepts vital to communicate scientific procedures and results can only be attained by turning to professional artists, although these are not usually familiarized with the terms, concepts and discipline being addressed. This calls for an extremely well-established partnership between the artist and the scientists and this was also the case for the presented poster.

The story board started to take shape early on and the action begins with a conversation between two fungi over the phone, a scene placed higher than the remaining ones in order to be read first. *Aspergillus* declines the invitation to a party later on. Several works of art are depicted at this party and many fungi are present, soiling and defacing them. Our "victim" only shows up at the place next morning but is retrieved by the scientist's cotton swab and taken to the lab for further analysis. Being the only one retrieved or the only one healthy enough to grow on a petri dish, he quickly becomes the scapegoat and leaves us with the question: Wrong place, wrong time?

Scientific communication is not always laid out in a simple and understandable language. Conventional forms have always worked on specialized audiences and detailed complex information is needed to advance science but, nevertheless, comics have shown to deliver scientific information with accuracy and they are seen as lighter and more enjoyable to look at and read than the same amount of information delivered as a text form or even in graphics. In a crowded poster session, in a crowded symposium or congress and where attendants are limited in time and pulled in different directions, this advantage can prove crucial in attracting attention. The poster "Wanted Dead and Alive: Guilty Biodeteriogen or Innocent Scapegoat?" (Fig. 1) presented at the IBBS Conference "New Trends in Cultural Heritage Biodeterioration" can add to this theory, as it got a very positive feedback and was granted the Best Poster Prize of the conference.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ibiod.2020.105092.

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