Far From Reality: Scientific Visualization

Stefania VARANO*1

Abstract. Universe is generally perceived as made of colorful and detailed objects, in which lights and shadows reveal fascinating geometries. Nonetheless, astronomical observations are mainly made of numbers representing the incoming data, which are often converted into images, in order to be better understood. The display process implies a set of rules for encoding the information in a visual form, but this code is not always acknowledged. When visual representations are used to display invisible data using highly figurative analogies (i.e. imitations of reality), they can lead to misinterpret nature of the data. We propose the use of more arbitrary and less figurative representations and investigate the suitability of multi-sensorial representations, testing them with both seeing and visually impaired people.

1. Introduction

In this article I present my PhD research project in Science Cognition and Technology at the Philosophy Department of University of Bologna, Italy, with which I graduated in June 2016. The title of my thesis is "Visual and sensory representation of invisible science". The main aim of the study was to inspect the use of images in scientific communication (also from a semiotic, semantic, philosophical, perceptive and cognitive perspective) and to examine the opportunity of using alternative sensorial representations.

Scientific visualization is the visual representation of data, in order to better understand and illustrate them to all possible audiences. The display process involves a code, i.e. a set of rules giving the correspondence between data and visual parameters [1], [2]. Normally the code is complex; not infrequently, however, it is tacit. This can cause the misinterpretation of the representation, particularly it shows invisible data in a densely figurative way [3], i.e. in strong analogy with visual referents and real objects (for example "artist impressions" of exoplanets, radio waves from a Quasar in false colors or gravitational waves represented as a sound).

We argue that, mainly in case of invisible signals, the use of more arbitrary and less figurative representations can harvest a more conscious fruition, also allowing to overcome some of the cognitive limits of images.

2. Description of the study

Scientific visualization is intended here as any visual representation of quantitative data, directly observed and measured or indirectly extrapolated and calculated. According to this definition, visual representations not necessarily are images: they can be diagrams, plots, etc. Within this framework, we make a distinction between different forms of data and representations: *data* can be *abstract* (percentage of literacy) or *concrete* (temperature, pressure, dimensions); representations can be *arbitrary* (plots, diagrams) or *figurative* (images, isophotes).

We focus on *figurative* representations of *concrete* data, *physically non-visible*. "Non-visible" objects are the ones that:

- do not emit light (Fig.1a);
- are too small to interact with light (Fig.1b);
- are not accessible to instruments capable of receiving the emitted/reflected light (Fig.2).

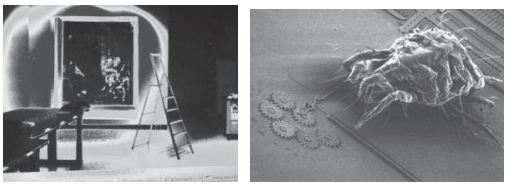

Fig 1. (a) Pseudo-colors representing the temperature (Infrared camera, false colors reported in greyscale); (b) Acarus close to a nanotech motor (Scanning electron microscope, greyscale).

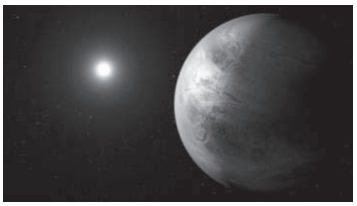

Fig.2 Artist's concept of one possible appearance of the planet Kepler-452b.

The use of images implies, as for many other cases in communication (such as metaphors, for

*1 INAF – IRA Istituto di Radioastronomia
stefania.varano@inaf.it

example) a *reading contract* [4], i.e. the code to be used to "interpret" the representation. This "contract" is usually stated in the original caption of the image, which not always complements the image in all its uses. In addition to that, sometimes visual representations are designed in order to be the most realistic possible and to recall reality. Nonetheless, since we represent numbers, we could in principle use whatever other sensorial stimuli capable of representing the presence of a signal overcoming the background noise. This necessary implies the use of abstract, non–figurative representations.

We explored the option of creating multisensorial representations and we studied the potential of such representations. First of all, we studied the state-of-the-art of alternative sensorial representations of scientific subjects (not only astronomical), determining how the less realistic ones seem to pose less displaying constraints (due to their estrangement from reality): this means they can enclose more parameters, i.e. more data. Abstract representations are also more engaging and challenging, even if perhaps less «emotional». Moreover, synesthetic representations have the potential of reaching different sensorial abilities.

With these findings in mind, we designed our own non-figurative representation and tested different version of it with various audiences, in order to attest its possibilities and limits.

3. Experimentation

We produced a tactile and acoustic map of radio waves emitted from celestial objects in a region of the sky, which makes use of tactile and auditory parameters not necessarily corresponding to their visual analogues.

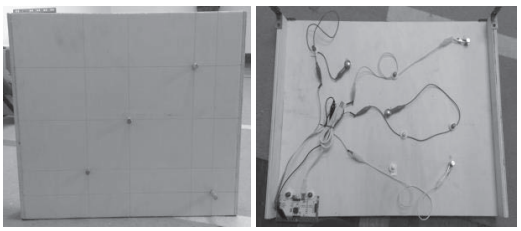

Fig.3 Our synesthetic representation of the sky.

We carried out a complete experimentation using a tactile, an acoustic and a synesthetic map of the sky (showed in Fig.3), the spatial position representing the position of the object in that portion of the sky; the physical heights of the bolts' column the different intensities of the signal (according to a direct proportionality) and different frequencies (different pitches of sound) the different distances from Earth, according to the relation "higher frequencies → closer objects".

The testing involved both seeing and visually impaired audiences: while using representations involving touch, we also acknowledged their diverse abilities and habits.

4. Results

This study showed as facing and exploring very abstract representations can be really hard in terms of noticing and choosing the elements worthy focusing on, since each feature seems equally important. We believe this gives strength to the experience, since this is exactly how science works: choosing what to study deeper in detail among many apparently equal possibilities.

While exploring the representations, many looked for analogies with their personal experience: larger extension of the arm was interpreted as a bigger distance by blind users, users that knew about the Doppler Effect related the difference of the pitches to the fact that signals were approaching or moving away from them. This means that the parameters of the representation have to be carefully and consciously chosen in order to be as much possible unrelated to reality

The representations implied low emotional engagement (no «wow» effect). This triggered an easier identification of the presence of a code, the understanding of which re-introduced the emotion (this is what the Universe "looks like" when you study the invisible).

Our results show a significant progress in terms of engagement of a disabled audience, presenting interesting cues for future research in education, implementations for science centres and creation of projects for the integration of sensory impairment.

Reference

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