

Eurekadabra: Science, Technology and Magic

Eurekadabra: ciencia, tecnología y magia

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ABSTRACT

When we witness an event considered as magical, we are facing an event in which natural rules are apparently broken by the use of supernatural forces. Technology, on the other hand, helps us to break down the barriers of the human being's capacities, amplifying them to the point that they seem supernatural. This article aims to reflect on how advances in science and technology have made possible those events considered as magical and supernatural, and how they have been used historically to redefine the word “supernatural”, and finally how magical effects can serve as a driving force for technological innovation.

Keywords

Science; technology;
magic; supernatural

RESUMEN

Cuando presenciamos un hecho que se califica como mágico o sobrenatural, estamos frente a un acontecimiento donde, en apariencia, se violan reglas mediante fuerzas desconocidas. La tecnología nos ayuda a romper las barreras de las capacidades del ser humano, las amplifica, hasta el punto de acercarse a lo inexplicable. El presente artículo pretende reflexionar sobre cómo los avances de la ciencia y la tecnología han generado eventos considerados mágicos, y cómo se han utilizado históricamente para redefinir lo sobrenatural y, finalmente, de qué manera los resultados son el motor de la innovación tecnológica.

Palabras clave

Ciencia; tecnología;
magia; sobrenatural

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Introduction

Without delving into the topic, one might think that, over time, an evolving system changes continuously, which would reflect a linear developmental progression; however, it has been established that evolutionary processes follow exponential growth rather than a linear rate of change (De Boer, 2010; Murray, 2004). This form of evolution is not subordinated to biological processes only, such as the cellular replication or the evolution of species but we can also observe it in the development processes of new scientific knowledge and technological advances.

In the 1960s, E. Moore, INTEL cofounder, noted that the number of transistors in a microprocessor would grow exponentially as it doubled every two years. This discovery is known as Moore's Law (Denning & Lewis, 2017). While this law was established empirically, its operation has been proven until recently. In parallel to Moore's Law, Kurzweil establishes in his accelerated return law that in the last 100 years, we have advanced the equivalent of 20,000 years, if the rate of technological advances follows a linear behavior (Kurzweil, 2004).

Most of the advances, discoveries and contributions made by the researchers are subject to be published in specialized journals, which are indexed in different databases for future consultation. Together with Web of Science (WoS), Scopus is one of the databases with the largest number of indexed references (Martín-Martín, Orduna-Malea, & Thelwall, 2018; Mongeon & Paul-Hus, 2016). By inquiring into databases, and as a test exercise, we can easily find that, in the last 150 years, there has been an exponential increase in publications including the word "technology" in their title, abstract or keywords (Figure 1).

In light of this situation, where there is increasingly more information on the functioning of our environment, it would be logical to assume that at the same time, there would be less space for studies and publications that have as central topic something that goes against the laws of nature.

A law of nature can be defined as a hypothesis that has been confirmed based on experimentation and, thus, accepted worldwide, i.e., a phenomenon can also occur if certain conditions are met (Ayer, 2015). If we think of the Neanderthal man, at the epoch in which survival depended on hunting and harvesting, we see a human being interacting intimately with nature; hence, the observation and knowledge of their environment were fundamental to obtaining the greatest possible benefit from everything available to them.

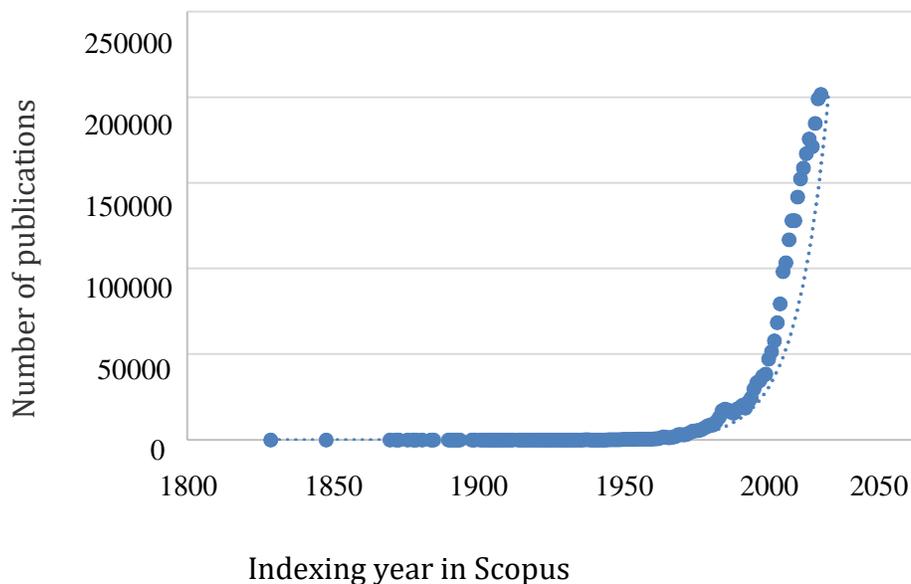


Figure 1. Evolution of scientific papers indexed in Scopus database presenting the word “technology” in their title, abstract or keyword. It is presented in an exponential tendency line with an $R^2=0.94$
Source: developed by the author based on Scopus data.

Based on this observation, it was inferred that in nature, there were *forces* that could dominate him as well as other beings. Therefore, the human being understood that controlling these forces and by infringing natural laws, he could dominate his physical context. With the intention of controlling these forces, man started to practice different rituals (Atran, 2007) that would eventually give birth to ceremonial magic (Forland, 2008).

At present, the concept of magic still retains the meaning of art or occult science that is executed through certain acts, words or with the intervention of conceivable beings contrary to the laws of nature (Royal Spanish Academy, 2017). Generally, a more fictional idea of this concept related to illusionists and magicians, always comes in mind. In this sense, as García-Molina (2011) points out that while science is seeking to explain the mysteries of natural phenomena, magic tries to hide these principles and, most of the time, distorts them. Despite these contradictions, science, technology and magic have crossed paths in more than one occasion; this synergy has not only helped to disseminate different technological advances at different epochs but it has also fostered the development of technologies that nowadays are considered trivial.

This paper aims at presenting a brief overview of some events that, in other epochs of history, ascertain how the progress of science and technology has made advances possible that were once labeled magical, and redefine that which, at some point in history, was considered supernatural. We will see how technology presented through this concept of magic has ended wars; the way magic has been involved in the beginnings

of robotics or how the mind of a magician projected the emergence of special effects that are common in cinema nowadays; and lastly, how technology has been classified in the realm of magic until it was mastered and understood.

Magic: first robots and virtual assistants

An event, to be considered magical, will depend on the epoch and place in which we live, since the interpretation of what we observe has to do with the knowledge and experiences an individual accumulates. The semantics of the concept of magic is modified to the extent in which science and technology advance, until both concepts can relate without any problem.

When we searched for papers that included the word *magic* in their title, abstract or keywords in Scopus database (Figure 2), we found that the use of this term has increased exponentially since 1833 (Figure 2a). Among different study publications, physical sciences, chemistry and engineering are the studies that use the term *magic* most (Figure 2b), these are subjects that are, by nature, developers and users of cutting-edge technologies.

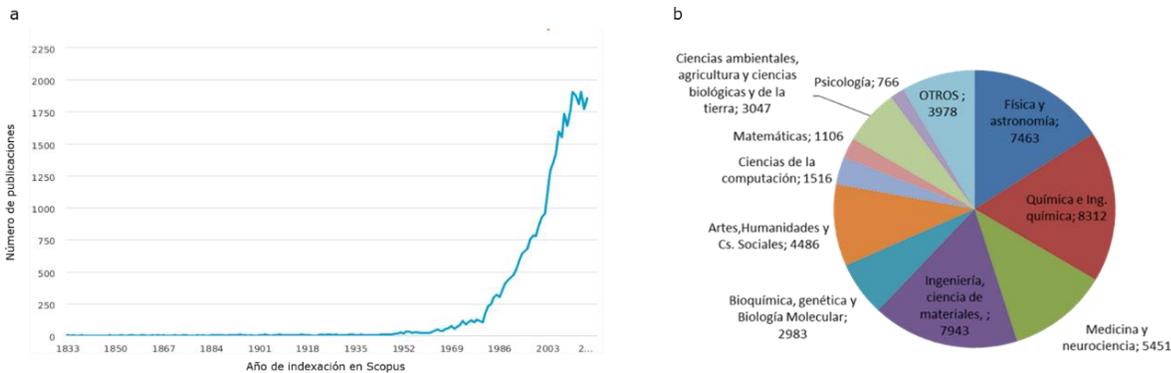


Figure 2a. Scientific papers indexed in the Scopus database, which include the word *magic* in their title, abstract or keywords
Source: developed by the author based on Scopus data.

Figure 2b. Articles using the word *magic* classified by fields of study in which the different papers have been published
Source: developed by the author based on Scopus data.

The first value of Figure 2a, from the year 1833, corresponds to a series of letters written by Scottish scientist David Brewster, and addressed to his friend Sir Walter Scott. These letters were published in the *Journal of the Franklin Institute* and subsequently, in the book *Letters on Natural Magic* (Brewster, 1834). In these letters, Brewster illustrates the different scientific principles and methodologies that were behind the magical phenomena that at that time were considered supernatural; the topics were related to optics, chemistry and mechanics. These letters aimed at providing Sir Walter Scott (and the readers) with tools to construct logical reasoning in light of the different superstitions of that time.

Brewster in his letters defined as a magical fact anything that exceeded the limits of human understanding, as well as anything that generated curiosity and wonder. Along these lines, one of the effects of natural magic described by Brewster, is the use of automata, very popular devices at that time (Sharkey & Sharkey, 2006). An automaton is a machine designed to develop a sequence of operations automatically or to respond to specific instructions, even though some of the more primitive machines were designed to give the illusion of autonomy by hiding someone in the interior of the machine to operate it.

One of the automata described by Brewster is the one designed by Thomas Irson, which was presented at the court of Charles II. This automaton consisted of a wooden head capable of responding through a voice to different instructions or questions made by the court attendees. If we think of this situation in the present, a supernatural explanation would probably be more complex given the increasingly more common presence of different virtual assistant in our homes such as *Siri* or *Alexa* (software designed to assist smartphones users through instructions) that can achieve practically the same results as Irson Brewster's automaton, even though the technology involved behind both devices is far different.

While today, virtual assistants interact with us through algorithms, microphones, connection to the Internet and enormous databases; the automaton described by Brewster, on the contrary, used a simple tube coming through an adjoining room connected to the wooden head; hence, making it easy for an assistant to speak from a room and whose voice was heard directly from the automaton.

Automatic opening of the doors and the power of the gods

While automata gained popularity in Brewster's time, their invention goes back several centuries. In Alexandria, during the I century B.C., the figure of Heron of Alexandria, also known as *Mechanikis* (the Machinist) emerged (McCourt, 2012; Papadopoulos, 2007). Heron was a prolific mathematician in the field of surface and body volumes, as well as a renowned engineer responsible for, among other advances, creating the first steam engine and describing the first automaton. Another of his virtues was his ability

to create devices that had practical applications that, from the standpoint of the inhabitants of Alexandria, could only be the product of the power of the gods.

One of his most famous inventions was the creation of an automatic door opening system for a temple (Papadopoulos, 2007). As he arrived at the entrance of the temple, the priest would light a flame to invoke the gods who responded by opening the doors that allowed him to enter the temple. Behind the scenes, the flame would heat up a receptacle filled with water which was hidden from the sight of whoever would go to the temple; once the water in the receptacle was boiling, the steam produced would trigger a series of counterweights that activated a pulley system that finally opened the doors.

Heron understood that maintaining the illusion of his creations was crucial to continue to sustain the acceptance of those that observed them. Heron took great care in not raising any suspicions on the operation and mechanisms behind the design of his creations, since any exaggeration in size where something could be hidden would raise skepticism among the observers (Murphy, 1995).

Interpreting technology as magic

From the historical events described above, we note that the interpretation of what the spectator witnesses is implicit; the knowledge that the observer possesses plays a fundamental role on the functioning of what they are seeing.

By 1856, Napoleon's army controlled part of Algeria; however, he worried about the uprising and growing influence of a religious tribe known as the Marabout people. The Marabout people gloated over having the ability to make miracles through miraculous forces, which made it easy for them to influence other local tribes in becoming allies and fighting against the French. Hence, the French government decided to show the Marabout people that France was superior in everything, even in the field of the supernatural.

Therefore, the French government contacted Jean Eugene Robert Houdin, a French magician, expert in using the latest technological advances of the time for recreational purposes.

Robert Houdin, known as the father of modern magic, performed regularly at his own theater. He was entrusted in showing the Marabout people the power of French magic. By observing what the Marabout people were doing, Houdin realized that in light of the simple tricks of the tribe, his experiments seemed miracles. Therefore, he designed an illusion that would terrify the tribe; he invited one of the strongest warriors to lift a small wooden box which he did effortlessly on the first attempt, but after making a small gesture by which Houdin intended to take away the warrior's strength, the latter was incapable of moving the box. The Marabout people did not know of the existence of electromagnetism

which Houdin applied to activate a mechanism so the electromagnet in the box would be attracted to the metal floor. As second act, and to increase the terror effect, the warrior, in trying to lift the box once more time, felt to the ground convulsing heavily.

The device used was created to generate, at the magician's will, a strong electric discharge to whoever would touch it which produced an electrocution effect. The Marabout people had never faced electricity, thus they assumed that it was a supernatural force. Therefore, they accepted that the French were superior to them and withdrew their intention of confronting them in a war (Collanges, 2014; Roberson, 2016).

The 19th century scientific theaters

By the second half of the 19th century, theatrical venues were more sophisticated given the existence of new stage technologies. Larger spaces were being built to hid complex mechanisms and assistants aiming at creating greater impact illusions on the public (North, 2001).

Many magicians understood that the use of the latest scientific advances, together with the lack of knowledge of most people of their operation, could provide them with great material for their theater performances. Performance presenters would take advantage of the superstitions of the general public of the time to explore and test the use of *obscure* scientifically advanced mechanisms (North, 2001) that arose from the inventors' minds.

Therefore, a theatrical movement that combined science and entertainment concepts emerged. These venues were known as scientific theaters (Vanhoutte & Wynants, 2017). Some of them used optical illusions and mirror games to create phantasmagorical appearances on stage (Lachapelle, 2008 and 2009), which had an effect quite similar to what we currently know as holograms. These magicians, who called themselves professors, redefined the meaning of magic and science besides endowing technical advances with an aura of mystery to astonish the audience attending their performances. There was no clear distinction between technological advances and magic for the popular mentality of the time. The public would marvel indistinctly at demonstrations of magic lanterns, phantasmagoria or fireworks. Henri Robin, one of the most active magicians of the epoch, claimed that without science, people were no longer entertained (Vanhoutte & Wynants, 2017).

Magic and the creation of special effects in cinema

Illusionists and their performances were instrumental in promoting the cinema industry. By the end of the 19th century, the invention of the *cinematographe* was beginning to

spread in Europe due mainly to the work of the Lumière brothers. The first public presentation of their invention was held on December 28th, 1895; George Méliès, the French magician, was among the attendees (North, 2001).

Méliès, who had acquired Robert Houdin's theater, was looking for new attractions for his shows; he thus encountered in the Lumière's invention a source of new possibilities. However, when he tried to acquire the *cinematographe*, the brothers refused to sell it since, according to them, their invention was a device closer to science than entertainment. Faced with the impossibility of acquiring the *cinematographe* directly from the Lumières, Méliès purchased similar devices from other inventors and tried, at the same time, to build his own prototypes; hence projecting his first works at the Robert Houdin theater, in 1896.

Méliès began seeking the possibility to recreate his illusionism performances in his movies. He therefore built what is considered today the first cinema studio in history. This studio had different mechanisms that made staging possible. As recordings progressed, he accidentally discovered the camera standstill technique by which he could achieve appearance, disappearance or transformation effects. He also experimented with image overprint, illusion of perspective and fades to black.

Méliès developed a range of special effects to exploit the potential of the camera itself. A magician on stage manipulates what the spectator sees and interprets. Until that moment, illusionists used curtains and smoke on the stage to mask the mechanisms through which their illusions operated. However, Méliès had discovered a new way of hiding what he did not want the spectators to see, and thus, giving birth to special effects.

Science, technology and magic in the renaissance

The human being has always been inherently interested in the inexplicable and the supernatural. Hence, scientific and technological advances are generally accompanied by the advent or resurgence of supernatural or magical beliefs (Busch, Watson-Jones & Legare, 2017; Garrett & Cutting, 2017; Shermer, 2002). We can take as an example what occurred during the Renaissance cultural movement.

This epoch is highlighted by the emergence of countless technological innovations in different fields to provide solutions to the needs of the time, in addition to the emergence of relevant figures that, to this date, we admire for their creations and findings, such as Copernicus, Galileo or Leonardo da Vinci.

Luca Pacioli was a Renaissance mathematician close to Da Vinci; he was interested in bringing mathematics close to the public at large. To do so, he gathered a large quantity of mathematical principles that he presented in an entertaining fashion to the people of that time. He adorned these principles with dynamic and appealing

presentations, stories and elements that transformed them into true magic games. Hence, his work became what is known today as the first book of magic in history which Pacioli titled *De viribus quantitatis (The power of numbers)* (Nunes dos Santos, 2014).

The Renaissance was characterized by a reaction to what had occurred in the Middle Ages, where morality and aesthetics were governed by strict guidelines. On the other hand, the Renaissance exalted the cult to beauty and the human being's capabilities, as well as nature contemplation. This contributed to establishing the observation of the environment based on science, but also the revival of mythology, magic and alchemy.

During this period, some thinkers began to reflect on the relation between technological advances and phenomena considered magical. Tomasso Campanella, one of the most influential philosophers of the Renaissance, described magic as a practical art in which properties of the elements present in nature were used to produce surprising and unusual effects (Hall, 1993); i.e., by manipulating natural causes of certain phenomena (through the development of technology), man could go beyond his own physical limitations.

Along these lines, Campanella claimed that "technology is always called magic until it is understood, but, after a certain time, it transforms into common science" (Watson, 1997). From Campanella's statement, we can infer that when magic is transformed into common science, we are acquiring knowledge. Based on Campanella's words, we could rewrite his concept of magic and technology as follows: technology is always called magic until it is understood, but after acquiring the sufficient knowledge it is transformed into common science. Centuries later, Arthur C. Clarke, the science-fiction writer, reformulated this statement into what is known today as Clarke's third law: "all sufficiently advanced technology cannot be distinguished from magic" (Clarke, 1973).

Magic and technology today

The concept of magic that existed at the epoch of Heron has undergone many changes to this day. For example, we are no longer surprised when approaching a mall and standing in front of the entrance, the doors open automatically since sensors, engines and rails are of common use, thus, man is no longer amazed at their existence.

Many of the scientific publications that include the word magic, shown in Figure 2, are journals of physics publishing research on the magic-angle. This magic-angle has been established precisely at 54.7° , and has different applications; e.g., in the area of the RMN spectroscopy (Bydder, Rahal, Fullerton, & Bydder, 2007). This angle improves image resolution; however, if certain structures are oriented to it, they can generate measurements errors. Hence, magic is identified through data obtained from technology; obtaining them otherwise would be impossible.

How could magic be defined nowadays? According to the foregoing reflection, all that is considered magical are events in which the established laws of nature are transgressed which causes amazement or surprise. With the exponential growth of the development of technology, there are few barriers that can escape logic and fewer natural laws that can be transgressed; hence, it is increasingly more difficult to lose our sense of awe. Then, what could make our current technological developments magic? Or, How could that sense of awe be achieved with technology?

Arturo de Ascanio, an influential Spanish magician, claimed that a magical effect has two parallel lives, which he named *external life* and *internal life* (De Ascanio, 2011). On the one hand, there is the magical effect that the spectator sees or perceives and then interprets as magical (the doors of the temple that open through the action of the gods (represent the external life), and on the other hand, there are the mechanisms or techniques that remain hidden and allow executing the magical effect (the steam and pulley mechanisms represent the internal life). Hence, for technology to generate the astonishment that a magic would achieve, it should have these two edges: a simple external life without taking into account the complexity of the internal life.

If we take into consideration the most successful technologies and the reason of their triumph, we can explain said success through the analogy described above: simplicity of the external life which is not necessarily related to the complexity of the internal life. A smartphone, for example, has fewer buttons on its touch screen making its use easier; thus, among many other things, smartphones have had more success.

The technological simplicity delivered to the user is not related to the complexity of the hardware and software components present in the devices that render their operation possible. According to De Ascanio (2011), “under this external life, this visible life, not secret, things are occurring continuously [...] necessary things are occurring”. This is what the most successful cutting-edge enterprises and developers have understood. Who has not thought that the Google search engine is reading our mind when suggesting exactly what we are looking for? We do not ask ourselves what is the complex algorithm that operates behind Waze when it suggests the best route to reach our destination.

The advances in the field of artificial intelligence (AI) are in line with the previous definitions; it has been understood that besides the complex algorithms on which their operation is based, there must be a friendly interface for the user. Sharkey & Sharkey (2006) mention that: deception is crucial in the development of AI and robotics. These fields of technology must create the illusion of self-awareness and independent thinking; hence, this is where the success of these two variants lies. AI obtains and prolongs its success when the common user perceives that the device with which they are even interacting is intelligent, and he/she even is aware that it experiences emotions.

From the above we can conclude that technology as well as a magical or supernatural fact, have the same objective; however, in appearance, they are expressed through different means. Their common denominator is that both break the laws of nature. Only a few decades ago, it seemed impossible to change physical characteristics or components of our body, but with the advances in the field of genetics and biotechnology, their manipulation and modification have been made easier.

It is currently more common to implant technological devices under our skin in order to obtain new characteristics or to correct flaws (Kim *et al.*, 2010; Smith, 2008). An example of this is the case of a 39-year-old man, a professional of casino games, who decided to have small neodymium magnets implanted in his thumbs and index fingers to help him control the dice he used in the games whose interior had also been modified with magnets (Kruavit & Numhom, 2008). Currently, scientific developments have made it easier to insert subcutaneous implants without modifying a range of genetic features through manipulating our DNA, which has given rise to an increasing number of biohackers (Sanchez, 2014).

Conclusions

In conclusion, technology is helping us to break down the boundaries of man's capabilities; it has amplified them to the extent that they seem supernatural. We should ask ourselves whether the role of technology in the future (and which already shows) is to act as a supernatural force that defies any logic.

Based on the stories narrated in this paper, we see that magic is far from being incompatible with technology; they should be understood as sister arts. As human beings, since our epoch of hunters and harvesters, we have felt attracted by these forces and we have tried to tame them. We like to see rules break down because it helps us knowing that it is possible to do so. When we watch a magic trick being performed or an illusionist on stage, we ask ourselves: How did they do it?

However, this question has been transformed through history; now we think: can I achieve this? Hence, we should understand magic as an art that plays a mobilizing role showing that the possibility of doing things that go beyond what has been considered so far as supernatural exists and that the laws of nature can be broken.

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